Licensing Databases on EMC and VMware Technology

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1 Understanding Licensing is Critical to Your Organization

Underlying most systems, which are critical to an organization's operational success is a Relational Database Management System (RDBMS). While there are alternatives to RDBMS that are emerging, the vast majority of the world's information transactions and interactions use RDBMS technology. Why is understanding database licensing so important to most organizations? There are several compelling reasons that we have developed over the years of successfully helping customers at House of Brick (HoB). These reasons include:

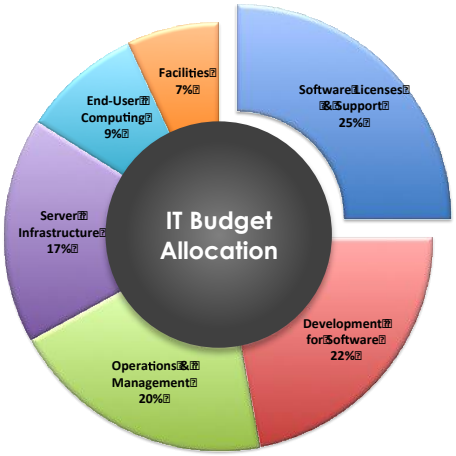
- Cost,
- Complexity, and
- Value to Organizational Success.

1.1 Cost

The bottom line is that software is expensive. This is especially true for those critical applications that drive your businesses and organizations. As illustrated in this chart based on data gathered by Wikibon.com, software licenses and support represent the single largest line item in the typical IT budget. The cost of software is greater than the servers, storage, and network (server infrastructure) used to run those programs.

We have seen far too many customers who did not adequately understand their licensing obligations and requirements, and ended up costing their organizations many millions of dollars in unnecessary expense.

Figure 1: IT Budget Allocation



1.2 Complexity

In addition to being the single biggest expense that most organizations have, software programs, especially for business/mission critical databases and applications can be very complex to manage effectively. Database administration, for example, requires well-trained, and experienced individuals to keep the systems running optimally and consistently. They need to understand the implications of high availability, disaster recovery, patching, performance analysis/tuning, system health, provisioning, and validation, as well as to a minimal degree of competency - licensing. Missing any of these elements will keep the organization from receiving the full benefit of their software investment.

1.3 Value to Organizational Success

You might wonder why people go to so much cost and hassle to acquire and use these software programs. The answer is that they provide critical value to the organization's operations and success. We like to define mission critical applications in terms of career impact. For example if a mission critical system has severe problems, someone could be at risk of losing their job. These systems keep the organization performing its charter, and bring in the revenue required for ongoing operations. When a business has a critical system go down, that business is not just inconvenienced, it loses money. Depending on the severity and duration of the downtime, it could even threaten the company's existence.

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Organizations need the technology that Oracle, Microsoft, and others provide in order to run these critical functions. For the reasons outlined above, understanding the complexities of licensing this technology is critical. This document will focus on key aspects of database licensing, with the following goals:

1. Maximize the benefit of virtualization and cloud technologies to create flexibility, availability, and recoverability, while shortening the time to develop and prove new, critical features and functions.
2. Create an environment that minimizes the licensing footprint within the scope of these benefits.
3. Decipher the misinformation that is being perpetuated throughout the industry related to licensing databases, especially when it comes to virtualization and cloud computing.
4. Demonstrate how solutions from EMC and VMware can create the optimum balance between operational and performance excellence, while controlling the impact of RDBMS licensing.

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2 RDBMS Licensing Basics

Relational Database Management System (RDBMS) software vendors understandably want to profit from their investment in software development, and we inherently recognize value when using that software. For this reason, commercial products usually require monetary consideration in exchange for a license to use the software as it relates to any given hardware configuration or software feature set. There are exceptions to this model, notably in the open source community. However, even in those cases there is a license that is agreed to simply through use of the software. With software licenses, there are terms associated with the license grant. It is very important to understand the terms of these agreements and to comply with them when using the software.

For commercial ventures, there is usually a profit motive to maximize revenue based on granting licenses to use the software. In addition, the commercial entity almost always desires to establish an ongoing revenue stream in the form of an optional support or maintenance agreement, which is usually integrated into the license agreement. These two agreements often become intertwined, and as the licensed product matures, the relationship between license and support can become increasingly complex.

In this section, we will provide an overview of licensing concepts and considerations for several popular RDBMS programs including:

1. PostgreSQL and EnterpriseDB (EDB)
2. Microsoft SQL Server
3. MySQL and Mariah DB
4. Oracle

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2.1 PostgreSQL and EnterpriseDB

2.1.1 PostgreSQL

PostgreSQL has one of the simplest licenses in existence for enterprise-ready RDBMS software. In fact, it's so simple it can be included in its entirety in this whitepaper (https://www.postgresql.org/about/licence):

> Permission to use, copy, modify, and distribute this software and its documentation for any purpose, without fee, and without a written agreement is hereby granted, provided that the above copyright notice and this paragraph and the following two paragraphs appear in all copies.
>
> IN NO EVENT SHALL THE UNIVERSITY OF CALIFORNIA BE LIABLE TO ANY PARTY FOR DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING LOST PROFITS, ARISING OUT OF THE USE OF THIS SOFTWARE AND ITS DOCUMENTATION, EVEN IF THE UNIVERSITY OF CALIFORNIA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
>
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As you can see, the only concerns are around the disclaiming of liability and there are no restrictions associated with the product's use. Therefore there is nothing to discuss regarding the types of hardware on which you can deploy it.

The only significant note is that it is the open source community that supports PostgreSQL is not a commercially liable entity. While some see this as an advantage, there is no support entity, so there is no support contract. That means there is no support service level agreement (SLA). To use a popular phrase, there is no "throat to choke" when something goes wrong. This makes some companies nervous and in some cases prevents them from considering such software either as a matter of organizational policy, or as a result of applicable regulations.

2.1.2 EnterpriseDB

We discussed PostgreSQL first because it is the foundation of EnterpriseDB (EDB). In addition to being a product name, EDB is a commercial entity that has emerged to take on the challenges of supporting customers who desire to use PostgreSQL in demanding mission-critical environments, and who also require support SLAs.

In addition to serving as an integrator of many open source tools surrounding an enterprise RDBMS, EDB offers proprietary tools as well as support contracts that cover the entire software bundle. As such, they are extending the PostgreSQL license agreement as it relates to their service and proprietary components. If you download their software distribution, which includes PostgreSQL, you agree to the additional terms specified as well as the various licenses governing the bundled open source software (http://www.enterprisedb.com/ba/foss-licenses). As with the base PostgreSQL license however, the EDB licenses are not particularly onerous and the entire agreement fits on a few short pages.

There is no additional cost to purchase the core bundle based on PostgreSQL. However, there is a suite of proprietary products called "EnterpriseDB Tools", for which separate licenses can be purchased and licensing costs appear to be affected by hardware choices. Currently there is

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no public price list, but various TCO analysis sources suggest costs are less than one-third of the cost of software available from their major competitors when running on comparable hardware. EDB is funded primarily by support agreements based on the number and size of supported instances.

2.1.3 Storage Choices

While selection of storage technology does not directly affect the purchase or support cost of either PostgreSQL or EDB software, there are considerations that may apply. These are discussed generically for all RDBMS platforms within the various storage solutions outlined in this white paper.

2.2 Microsoft SQL Server

SQL Server licensing can be complex, mostly due the multiple ways of licensing and acquiring the software. There are three different editions and there are different rules for licensing each edition—per core or per user/per device. There are also different packs and purchase units that may affect the number and types of licenses required to be purchased. In addition, virtualization rights (which will be discussed further below) add another layer of complexity, and may change depending on whether Software Assurance (SA) is maintained with Microsoft for the licensed products.

2.2.1 Microsoft Documents

There are three main documents that determine your rights to use SQL Server within the licensing terms. The first is the Product Terms document, which was previously referred to as the Product Use Rights. This is the key aspect of your license agreement with Microsoft, which enables you to use the software that you licensed. With Microsoft, everyone typically uses the same Product Terms and the only variable is the cost paid for the license.

The next document, which needs to be read and understood, is the End User License Agreement (EULA). This agreement comes with the software and must be accepted as part of the installation procedure. Most of the information in the EULA is pretty straightforward and refers back to the Product Terms document.

The last document that you need to be aware of is the Microsoft SQL Server Licensing Guide. This document describes, in plain language, how Microsoft interprets the other two documents and provides multiple scenarios to help you understand what licenses you need to purchase. This licensing guide is typically a very accurate representation of the organization's actual licensing requirements. All of three of these documents are available on Microsoft's website.

2.2.2 Special Organizations

For certain types of organizations there are special rules for licensing. These organizations include medical, non-profits, independent software vendors (ISV), and service providers. However, licensing methods for these special organizations are outside the scope of this document and are only being included to make you aware of their existence.

2.2.3 Editions of SQL Server

There are three versions of SQL Server that are available to be purchased - Enterprise, Business Intelligence, and Standard. There is a fourth version called SQL Server Express, but it is a free

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version with limited functionality. The differences in the editions relate to the amount of resources that the database is allowed to use and which features it has available to it. In the past, features from Enterprise Edition tend to move into lower editions with newer releases. As an example, backup compression was previously an Enterprise-only feature, but is now available in all paid editions.

Standard Edition has the core database engine and includes SQL Server Reporting Services (SSRS), SQL Server Analysis Services (SSAS), and SQL Server Integration Services (SSIS). This edition is limited to using only 128 GB of memory and four sockets with four cores each, for a total of 16 threads executing simultaneously.

Business Intelligence Edition has all of the features of Standard Edition and also maintains the same level of resource constraints. There are however, additional features that focus on Business Intelligence operations.

Enterprise Edition has everything that Business Intelligence does, but it increases memory and CPU constraints to the limits of the underlying operating system. There are also many additional features available in Enterprise Edition. The latest features are introduced only in the Enterprise Edition, including AlwaysOn, in-memory tables, and improved encryption options.

2.2.4 Licensing Methods

SQL Server can be procured on a per-core basis, or on a per-server basis. When licensing per server, you must also purchase Client Access Licenses (CALs). CALs can be purchased on a per device or per user basis. Each edition, however, has different rules for purchasing CALs. Enterprise Edition can only be purchased per core; Business Intelligence Edition can only be purchased via server + CALs; and Standard Edition can be purchased with either method.

Like Oracle licensing, Microsoft uses a core factor table, which allows them to adjust pricing based on the CPU model. Currently, the most notable outcome of this table is that AMD processor cores are licensed at .75 compared to Intel processors, which are licensed at 1.0 per core. The minimum amount of cores for a SQL Server is four. So, even if your physical or virtual server has less than four cores, you still need to purchase four cores for this server.

2.2.5 Software Assurance

For Microsoft products, Software Assurance (SA) offers access to the latest patches and security fixes as well as license rights for newly released software versions. Another benefit of maintaining Software Assurance is that it provides more favorable terms for virtualization.

2.2.6 Virtual Rights

SQL Server licenses are attached to the physical hardware on which the database runs. These licenses can only be moved once every 90 days under normal circumstances. However, when you purchase SA, it comes with a right called License Mobility, which allows you to move the licenses as often as you want. In a cloud environment where you do not know when the virtual machine moves, absolutely need to have SA in order to maintain compliance with licensing terms.

2.2.7 Hyper Threading

Microsoft only requires you to license physical cores, and not logical cores. In a virtual environment, there is no way to determine if the vCPU is running on a physical core or hyper-

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threaded core. When licensing a virtual machine (and not the underlying host), you must have licenses for total number of vCPUs assigned to a virtual machine.

2.2.8 Storage Choices

While selection of storage technology does not directly affect the purchase or support cost of SQL Server, there are considerations that may apply. These are discussed generically for all RDBMS platforms within the various storage solutions outlined in this white paper.

2.3 MySQL and Mariah DB

Oracle acquired MySQL as part of its Sun acquisition. The European Union did not allow Oracle to proceed with the Sun acquisition until they made certain binding commitments with respect to how they would maintain and support MySQL. Oracle has, for the most part, left it alone except to fold support into its service offerings. MySQL appears to still fall under the GNU General Public License (GPL).

Out of concern for Oracle's ownership, a group of developers made a fork of the code from the last non-Oracle branch. That branch is now called Mariah DB, the use of which is also governed by the GPL. The crux of the MariahDB license is that you may use it and distribute free of charge. Such distribution must include the terms and text of the GPL. However, any application based on MySQL/Mariah DB may also be required to fall under GPL/LGPL and/or the Free/Libre and Open Source Software (FLOSS) terms. The main concern is that source code for any such applications must also be made public. For that reason, the simpler and less encumbering terms associated with PostgreSQL may be preferable.

2.4 Oracle

In our observation, licensing Oracle is one of the most complex exercises facing IT professionals today. House of Brick has carefully studied the contracts and amendments in the Ordering Documents (order forms), as well as the definition (and sometimes attempted re-definition) of many of the key words, to arrive at an accurate understanding of the contract. With our guidance, Oracle licensing can be effectively managed. In this white paper, we make concrete and defensible assertions on licensing Oracle. We also include some historical background, which may help offer clarity on some elements of licensing as well. Approaches for negotiating with Oracle on licensing their products are also introduced.

While Oracle's base ordering documents are not substantially more complicated than those for EnterpriseDB, they are surrounded by various policy documents, only some of which are contractual. To make matters worse, Oracle sales professionals may sometimes make assertions that are not supported in any Oracle documentation. Finally, some customers succeed in convincing Oracle to amend their agreements for more favorable terms. These new terms are then protected by the contract's non-disclosure clause.

For these reasons it may seem difficult for most people to establish exactly what is binding and what is not during a purchase or comparison exercise with Oracle. For the purposes of this white paper, we will stick to the price list and contractually binding definitions.

2.4.1 Oracle Documents

There is one main document that determines customer rights to use Oracle within the licensing terms. This document is the Oracle License and Service Agreement (OLSA). Older versions of the master agreement may be called the Software License and Services Agreement (SLSA), or

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Oracle License Agreement (OLA), and newer versions of the agreement may be called the Oracle Master Agreement (OMA). For the purposes of this whitepaper, we will refer to the OLSA since that is the most common agreement in force with the majority of customers as of the date of this publication. A description of these agreements is available from Oracle.

While Microsoft uses standard agreement language that is not typically intended for negotiation, the terms and language of the OLSA may be (or have been) subject to changes through the sales process with Oracle. Therefore customers may have unique, or modified, terms that apply only to their environment or only to a particular negotiation. We have observed a history of Oracle's willingness to negotiate some terms and not others. Such modifications are protected by the contract's non-disclosure clause and may not be shared or discussed beyond contractors or consultants with a need to know, without permission from Oracle. The existence of the non-disclosure clause leads us to remind customers that whenever interacting with Oracle, they should begin by assuming all terms may potentially be negotiable.

The Oracle documents are an interesting collection of information. They can roughly be grouped into two categories—binding contractual documents, and non-binding educational and other documents. The factors that determine whether a document is binding or not is 1) if it is included by specific reference in your OLSA (or other master agreement), or 2) if it is specifically referenced as an amendment to the contract in an Ordering Document (customer-specific document citing license metrics, quantities, features, and pricing for a particular license purchase).

As cited in a blog post by House of Brick's CTO, Dave Welch, the Entire Agreement clause of the OLSA prevents any other representation, whether written or verbal, from being considered binding in the Agreement unless it is specifically referenced by that Agreement. The OLSA directly references two other documents, which make them contractually binding. The first is the Processor Core Factor Table, used to determine a ratio for various computer processors. Customers that contracted with Oracle using Oracle's contract template language around August 2008 may find the Processor Core Factor table integrated into their contract. The second is the Oracle Technical Support Policies document, which establishes your rights and obligations with respect to Oracle support.

Figure 2: Oracle Documents Contractual or Not

Oracle Document	Contractual?	
Ordering Documents	✓	Yes
Technical Support Policies	✓	Yes
Core Processor Factor Table	✓	Yes
Software Investment Guide	✗	No
Licensing Data Recovery Guide	✗	No
Technology Hosting	✗	No
Partitioning Policy	✗	No
Cloud Computing Environment Policy	✗	No

In addition to the OLSA, which is the basis for your contractual rights, and the other two explicitly referenced documents, there are several related documents that are not contractually binding (even though Oracle sales or audit professionals may assert otherwise). These documents are not contractual because they are excluded by the Entire Agreement clause of the OLSA. The fact that many of these documents may indicate that they are "for educational purposes only and may not be incorporated into any contract" may be

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accurate, but that is not what makes the documents non-contractual – the fact that they are excluded by the Entire Agreement clause does. Despite these documents' non-contractual status, they are often cited as if they were actually part of the contract.

We invite you to refer to House of Brick's blog for our latest observations regarding Oracle licensing.

2.4.2 Common Assertions that Are Not Contractually Binding

Now that we have established which policy documents are contractually binding pertaining to the use of Oracle technology, we now need to review the common assertions that our customers tell us that they are hearing.

Figure 3: Oracle Licensing Common Assertions

Common Assertion	What Is True
You cannot use soft partitioning to license a sub-number of cores in your server	Although soft partitioning with VMware is mentioned as a restriction in Oracle's Partitioning Policy Document, we established that this is not contractually binding (this document is excluded by the master agreement's Entire Agreement clause).
You cannot use soft partitioning in a cluster	We think that the person who makes this assertion is confusing the server soft partitioning concept with licensing in a cluster concept. The Partitioning Policy document defines partitioning as a means to limit the number of cores in a server for licensing purposes. As such, soft partitioning doesn't apply to collections of servers. There is no such restriction in your agreement.
For vSphere versions before 5.1, if you put Oracle in a VMware cluster you have to license the whole cluster (This assertion stems from the capability in vSphere to vMotion within a cluster).	You only have to license the nodes where Oracle is installed and/or running. There is no obligation to license the nodes where Oracle may run until such time that Oracle programs have actually been installed and/or run on those nodes. This is true whether or not you use DRS Host Affinity Rules or some other tooling method, as the contract is silent on tooling or operations required to comply with your licensing obligation. The contract contains no prospective licensing obligation. Sample methods for establishing such protections are discussed in Appendices A and B.
With vSphere 5.1-5.5, you have to license every node attached to the same storage array. This also is sometimes re-phrased as "if you are running Oracle on a Vblock, you have to license every blade in that converged system" (This assertion is due to the ability in vSphere 5.1-5.5 to vMotion across clusters within a single vCenter)	If it is not installed and/or running there, then do not pay for the license.
With vSphere 6, you have to license every node in the whole enterprise (This assertion is due to vSphere 6's ability to vMotion from one vCenter to another one)	Again, the contract is silent on any prospective licensing obligation. Just because you could potentially run or install Oracle on a node in the future does not mean you have to pay for it now. A logical extension of Oracle's assertion is that since you could go buy another blade from your hardware vendor, you have to license that blade for Oracle in advance of the purchase.

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2.4.3 Special Organizations

While Oracle does acknowledge some categories of special organizations that might enjoy favorable discounts, and some standardized modifications to the licensing terms, these are outside the scope of this document. If you represent government, educational or other organizations that typically receive favorable licensing terms from software vendors, check with your software purchasing advisors for more information.

2.4.4 Editions of Oracle

For most Oracle products, RDBMS included, two high level editions may be purchased: Enterprise, and Standard. For RDBMS, the only "standard" edition available for purchase at the time of this writing is Standard Edition 2 (SE2). There is a third edition of RDBMS software, called Oracle Express (or XE), which is a free version with limited functionality and very restrictive licensing terms. The terminology and metrics are similar for both paid editions, and the differences are outlined later in this section.

House of Brick has observed Oracle taking the opposite approach to Microsoft by removing features from Standard and either moving them to the more expensive Enterprise edition or making them separately licensed features.

2.4.5 Oracle Licensing Metrics

There are various metrics that can be used to acquire RDBMS licenses from Oracle. The two most popular are Processor-based (which we have, and will continue to, focus on in this document), and Named User Plus (NUP). In the past and prior to VMware, our customers primarily used NUP licenses in development and test environments where the number of users was controlled. In our observation, with the use of sub-cluster and even targeted core licensing, many organizations can now optimize their Oracle license expenditure by focusing exclusively on the processor metric license for both non-production and production environments. Such strategies imply an additional commitment to administration of the environment to ensure license compliance, and can reduce both functionality and performance of specific VMs, but there is usually significant cost justification for doing so.

The discussion of processors and core counts in this document is useful in considering NUP licenses because they factor into the minimum number of licenses that must be purchased for the server on which the software is running. For Standard Edition(s) of Oracle database, a processor is defined as a physical socket on the server in which a microprocessor chip would be inserted, regardless of how many processor cores are on that chip. This means that with the imposed per-processor minimums, we can generally reduce the licensing cost by as much as 50% for the same hardware in cases where the entire user community can be identified and counted. This becomes particularly powerful when combined with specific-use and restricted licenses. We have observed as much as a 90% savings in some cases, however further discussion of these strategies would be beyond the scope of this document.

2.4.6 Definition of Processor

For both the processor based metric, and the NUP metric, you have to understand how a processor is defined to determine the number of licenses that need to be purchased (remember that for Standard Editions of the Oracle database, a processor is equivalent to a socket). As illustrated in the various OLSA documents that are readily available by a simple Google search, processor has a very specific definition.

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(This one was taken from http://www.oracle.com/us/corporate/pricing/olsa-ire-v122304-070683.pdf)

> Q. **License Definitions and Rules**
> **Processor:** shall be defined as all processors where the Oracle programs are installed and/or running. Programs licensed on a processor basis may be accessed by your internal users (including agents and contractors) and by your third party users. The number of required licenses shall be determined by multiplying the total number of cores of the processor by a core processor licensing factor specified on the Oracle Processor Core Factor Table, which can be accessed at http://oracle.com/contracts. All cores on all multicore chips for each licensed program are to be aggregated before multiplying by the appropriate core processor licensing factor and all fractions of a number are to be rounded up to the next whole number. When licensing Oracle programs with Standard Edition, One or Standard Edition in the product name, a processor is counted equivalent to an occupied socket; however, in the case of multi-chip modules, each chip in the multi-chip module is counted as one occupied socket.

Oracle's processor-based licensing metric is, well, processor-based. We suggest that you memorize this sentence in the contract regardless of your work role: "Processor shall be defined as all processors where the Oracle programs are installed and/or running." That's it! Your license is not enterprise-based, vCenter, SAN, NAS-based, cluster-based, or even server based. It is processor-based. You will find a materially identical statement in your contract whether it was executed in 1993 or 2016. "Installed" is past tense. "Running" is present tense. As such, there is nothing "prospective" in your Oracle contract language.

We often see sales strategies based on the claim that customers owe a license where Oracle software "might run." This is a direct contradiction to the plain contractual language stating that you must pay for a license where the software is actually installed and/or running. This attitude is reflected in a humorous comic that we came up with at House of Brick. We call the following illustration the "Oracle Parking Garage."

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Figure 4: Oracle Parking Garage

Just like you only have to pay for the spot where you parked your car in a garage, you only have to pay for a license for those processors where Oracle is "installed and/or running."

2.4.7 Processor Licensing

Early on Oracle attempted, but then repealed, a "power" licensing mechanism. The idea was to establish the compute power of the server on which the software was running as a license metric. The metric selected, which has endured to this day, was the count of processors in the server.

Back in the day when a socket contained one CPU with one (single-threaded) processing core, the term "processor" seemed like a straightforward metric and it was easy to figure out the associated price. At the time, there was no clarifying language or further definition required. The following sections discuss a list of technology and terms that have developed around the topic of processor licensing to help Oracle benefit from advances in CPU hardware. Some of the terms are no longer relevant, but the language Oracle adopted to account for them is sometimes exploited to confuse the license requirements resulting in an inflated price calculation.

2.4.7.1 Processor Speeds

Moore's law, which paraphrased says that processing power will double every two years, has been largely realized since Gordon Moore made the prediction in 1965. Historically, the simplest way to accomplish this was to increase clock speeds. But as clock speeds approached the limits of known physics, chip manufacturers were forced to look for ways to increase "power" using other techniques as described below.

Beyond clock speed, we saw the phenomenon continue through the use of faster components, better materials, reduced trace sizes, and increased component density. The most recent advances have slowed to incremental gains with trace sizes and component density also nearing the limits of known physics and natural materials, leading some to predict the end of Moore's law.

The implication of Moore's law on licensing Oracle programs is that it is important to maximize the speed of your processors, while minimizing the number of cores that the software runs on. This will maximize performance while minimizing license cost.

2.4.7.2 Parallel Execution and Processor Efficiency

Some real advantages developed as vendors, most notably IBM, began to develop processor architectures which allowed in-line processing of multiple hardware instructions allowing simultaneous completion within a single clock cycle. As stated above, Oracle moved in August 2008 to improve its licensing revenue on many such chips through the designation of a higher 1.0 processor core factor.

2.4.7.3 Socket vs. Slot and Multi-Chip Modules (MCM)

A now deprecated technology evolved at one point, which built multiple processors onto a single daughter board. These "modules" usually plugged into a motherboard via a "slot" as compared to the traditional socket, and were referred to by Oracle as multi-chip modules (MCM).

Oracle correctly established a policy and wording that identified these MCM as multiple processors for licensing purposes. In other words, if a module contained two or more processors – typically plugged into traditional sockets – then the licensing metric would consider the number of processors on the module (they would not be aggregated as one processor).

Around this time, Oracle adopted the term "socket" to be synonymous with the licensing term "processor" to clear up any confusion that may have existed regarding the licensing of multi-chip modules.

2.4.7.4 Symmetric Multi-Threading (SMT)

In addition to inline technology and the ability to complete multiple instructions per clock cycle, IBM introduced SMT technology to their POWER architecture. This allowed a single processing core to support multiple simultaneous threads of execution. Modern POWER processor cores support 4-way SMT, or four simultaneous execution threads. Oracle does not currently consider SMT as a factor of processor licensing.

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2.4.7.5 Hyper-Threading (HT)

Hyper-threading is Intel's answer to SMT and functions in a similar fashion. Because Intel is currently assigned a core factor of 0.5, compared to IBMs 1.0, Intel enjoys a 50% lower price for Oracle licensing over the cost for comparable IBM/POWER hardware. As the contract's processor definition refers only to processors, hyper-threading is "free" to licensees.

2.4.7.6 Multi-Core CPUs

Not long after Oracle introduced the term "socket", CPU vendors began to produce processors that fit into a single socket, but had multiple processing "cores" on a single chip. Again, IBM was a leader to market with this technology and quietly introduced it into its hardware lines. Few customers realized that the cores they purchased no longer implied the same number of sockets. Everyone moved forward with business as usual in terms of Oracle licensing where one core was the same as a "processor."

Around this time, however, Intel's architecture was gaining traction as a lower cost alternative to expensive RISC processors and traditional "big iron." Oracle also added support for the x86 platform for their budget-conscious customers, and the platform began to gain some traction. These same value-minded customers attracted to the x86 platform, argued that the performance was lower than with RISC systems and they wanted consideration from Oracle with regards to processor-based licensing.

When Intel next introduced multi-core processors, an argument was introduced that these 2-core chips were really one "processor" since they only occupied one socket. In response, Oracle introduced the terms "core" and "processor core" into its documents and began to make a distinction between cores and sockets while aligning the licensing term "processor" to mean a "processing core". At nearly the same time, they introduced the concept of processor core factor to address Intel and other factors that affected processing power, thus giving itself the ability to adjust license costs based on the processor architecture.

Oracle introduced multi-core chip discounts in its July 15, 2005 announcement (still available on its web site at of the time of this writing). A statement by an Oracle official at the time admitted the new Processor Core Factor of 0.75 was in response to competitive pressure from Microsoft SQL Server and IBM DB/2. The 0.75 Processor Core Factor allowed for six cores to be covered by four processor licenses. The new Processor Core Factor was adoptable by existing licensees without amendment.

The Processor Core Factors were brought into Oracle contract template language in 2006, and the tiers were further sub-divided to 0.25 for some performance-challenged SPARC chips, 0.5 for x86/AMD chips, and 0.75 for all other multi-core chips.

In contract template language around August 2008, the Processor Core Factor table was moved to a document external to the contract, but integrated into the contract by direct reference. At that time, Oracle also raised the maximum Processor Core Factor for many of the more recent RISC UNIX processors back to 1.0

It is important to note that RISC UNIX customers contracted prior to August 2008 may find that they have been grandfathered on the 0.75 maximum Processor Core Factor in effect at the time of their agreement. This means that as long as they have not allowed Oracle to attach amendment language to product Ordering Documents that specifically references the external Processor Core Factor document they will enjoy a discount because of the lower core factor.

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To date, this core factor assignment has been largely vendor-specific, but we are starting to see additional granularity appear in the published Processor Core Factor Table. While the core factor table originally reflected perceived relative performance of various vendors' processors, today it may have evolved into a political tool as well. An example of this is with Oracle-owned hardware, giving license advantages to Sun platforms.

2.4.7.7 Summary of Processor Licensing Concepts

The bottom line is, that in order to calculate the number of "processor" licenses required for purchasing Oracle Enterprise editions today, we take the number of processing cores (regardless of socket count or other aggregation) and multiply that number by the processor core factor for that processor architecture. We find that processor core factor either in the July 15, 2005 announcement, inline in the 2006 – July 2008 contract template language, or in the then-current Processor Core Factor table as specified in the August 2008 and newer contract template language. We have found that Oracle is in the habit of attaching contract amendment language to product Ordering Documents. Even if you are on a pre-August 2008 contract template, and have made a product purchase after that time, you may have experienced an amendment referencing the external core factor document. In cases like this, if you do not push back on any amendments to the Ordering Document referencing the external Processor Core Factor table, then the Ordering Document amendment takes precedence over the master agreement. In all cases, the Processor Core Factor calculation is done without consideration for SMT or HT.

No matter what anyone may assert, and regardless of their role (including Oracle Legal), there is no contractual obligation to license processors beyond the physical server(s) on which the Oracle software is installed and/or running. It is invalid to attempt to extend beyond these contract terms based on a server's participation as part of a server cluster, shared storage, or enterprise network.

2.4.8 Oracle Editions: Enterprise vs. Standard

The same history and terminology that applies to the preceding discussion applies to both Enterprise and Standard editions. The introduction of Standard Edition and its variants has been a strategy to enable smaller organizations to incorporate Oracle technology within tighter budget constraints. Oracle sales professionals almost completely ignore Standard Edition as a purchase option unless the customer specifically asks about it. Even then, they may attempt to discredit the idea. You should understand that the primary motivation for this is that Oracle rewards sales of Enterprise Edition much more heavily than the lower-cost Standard Edition. At the time of this writing, previous variants of Standard Edition are no longer available for purchase; only "Standard Edition 2" (SE2) is currently available.

With Oracle, a significant determinant of total cost of ownership is the choice of software edition and the various options and packs selected. Oracle sales will often push Enterprise Edition without any analysis of actual requirements. Prior to SE2, it has been House of Brick's experience that many customers can actually run enterprise-class workloads with Standard Edition. There are a few important differences between Enterprise and SE2 as far as licensing is concerned:

1. The term "processor" has a different meaning for SE2 licensing purposes. Instead of a "processing core", the term means a "socket" without regard to the number of cores. Therefore, when purchasing a processor license for SE2, you are licensing a physical socket. This implies that it is to the customer's benefit to maximize the core count on that socket in order to achieve the maximum benefit from the license purchase.

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Unfortunately, vendors have also recognized this dynamic and started imposing controls within their software to limit the number of cores actually used. As of the time of this writing, the maximum number of cores available in the Intel CPU line is currently 24. But both Oracle and Microsoft limit their standard edition software to use a maximum of 16 cores. It is unclear why they both use the term "threads" when describing the limit rather than cores, but independent testing appears to validate that the terms are being used interchangeably.

So, there is limited benefit to purchasing processors with more cores than the software-imposed limit of 16.

2. Oracle has introduced the following restrictions in the latest contract template language and SE2 Ordering Document amendment language:
    a. Oracle has limited the applicability of an SE2 license to servers that have a maximum *capacity* of two sockets. This means that if a server can accommodate more that two sockets, regardless of how many are populated, the server cannot be licensed for SE2.
    b. Oracle has introduced an imposed cap of 16 threads/cores (see previous item) with SE2. At this time, the benefit of having more cores than the Oracle kernel will make direct use of is debatable.
    c. Oracle has continued the Standard Edition Named User Plus per Processor minimum of 10 users.
3. Under the Standard Edition RAC bundle in SE2, Oracle limits the RAC cluster to two (2) sockets, which implies two single-socket servers in the cluster.
    a. For purposes of RAC, the two-node cluster has a maximum of 16 user threads/cores (eight per node).
4. Other RDBMS options, such as partitioning, cannot be licensed on any Standard Edition, including SE2.
5. Oracle Enterprise Manager (OEM) packs are not available for licensing with SE2. However, this may be negotiable in cases where customers have an extensive installation of OEM.
6. Enterprise features are obviously missing
    a. Data Guard is an Enterprise feature that is missing from SE2. It should also be obvious by now that "Active Data Guard", as a separately licensed feature, cannot be added to SE2.
    b. The "Parallel Engine" is not present in SE2. This is the technology that allows parallel query, which may be irrelevant to many customers. However, its absence also limits DDL capabilities such as "ALTER INDEX … REBUILD ONLINE" AND "ALTER TABLE … MOVE ONLINE". Another side effect of its absence is that RMAN backups are limited to a single channel.
7. Additionally licensed features that are frequently used in Enterprise Edition are not available for Standard Edition.
    a. This includes "options" such as Partitioning and Advanced Security.
    b. This also includes OEM packs, although it may be possible to get waivers to be able to incorporate your Standard Edition servers into your enterprise OEM infrastructure.

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Standard Edition (no longer available for RDBMS) is restricted to servers with a maximum capacity of 4 sockets. This allows cluster configurations of 4x1-socket servers or 2x2-socket servers.

Standard Edition One and Standard Edition 2 are restricted to servers with a maximum capacity of two sockets.

Legacy SE RDBMS customers in particular may want consider making the new SE2 limitations the subject of negotiation.

The SE2 RAC bundle can net significant license savings compared to the Database Enterprise Edition and RAC line items. RAC customers who can live with the two-socket per cluster maximum and eight user threads per instance maximum can realize substantial savings in both the initial license purchase and ongoing software update licenses and support. They may also consider a RAC alternative such as VMware HA, as outlined below.

2.4.9 Replacing Oracle Features with EMC and VMware Solutions

For House of Brick customers running Oracle Standard or Enterprise Edition software in a VMware virtualized environment with EMC infrastructure, many of the costly enterprise features, options, and packs are not needed. For example, instead of RAC for high availability, our customers are using VMware High Availability (HA) or Fault Tolerance (FT) as viable, if not superior, solutions. Rather than using Data Guard for Disaster Recovery (DR) replication, customers often get a more resilient solution with more comprehensive stack coverage (that is easier to manage) by using SAN replication technologies from EMC such as SRDF or RecoverPoint, coupled with Site Recovery Manager from VMware. House of Brick has long advocated that where multiple layers of the system stack offer similar functionality, architectural best practice should assume to leverage that functionality in the lowest layers of the stack. By virtualizing using VMware, we can encapsulate the entire system stack (operating system, middleware, application software, settings, database, etc.) and manage that virtual machine more effectively for HA and DR.

2.4.9.1 Determining RAC or VMware HA

While RAC is a powerful HA and scalability solution from Oracle, it is not the right solution for every situation. The following are circumstances where RAC may be the right solution. However, if these do not apply to you, then VMware HA may be more appropriate for your organization. It is worth noting that if your organization chooses to use Oracle RAC, then it makes sense to run your RAC implementation on vSphere. RAC and vSphere are 100% complementary and offer:

1. Explicit Service Level Agreement (SLA) of less than four minutes – VMware HA requires a reboot of the virtual machine, resulting in an SLA of about four minutes or less for most hardware manufactured during the three years prior to the time of this writing. It can be significantly faster with SSD. If you do not have a published SLA, your validated reboot time is sufficient, then RAC may not be the solution you need.
2. Rolling Upgrades – The use of Oracle RAC for rolling upgrades eliminates planned downtime that would otherwise be required for these operations.
3. Application Support for RAC – Do your applications have hooks into RAC's Oracle Notification Service? Such hooks allow application stacks to invoke functional branches based on the up/down status of the system stack components and the load balancing information for the services. In House of Brick's experience and observation, such hooks into the Oracle Notification Service are extremely rare.

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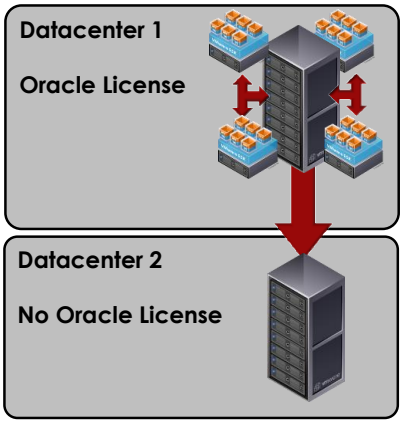
4. Horizontal CPU Scaling - As of the time of this writing, a single VM can allocate up to 128 vCPUs. System stacks that truly need more than 400 GHz of processing power including hyper-threading are increasingly and extremely rare.

If your application does not require any of the capabilities listed above, then you should consider VMware HA as an alternative to Oracle RAC. Eliminating this would save you $23,000 per processor (list price) for licensing RAC, and $5,060 per year in support (list price).

2.4.9.2 Example Architecture for VMware as Alternative to Oracle-Based DR

For disaster recovery using a typical Oracle-based methodology, you would need to license your primary server(s) as well as secondary server(s) for Oracle database. You may also need to license Oracle Active Data Guard for both primary and secondary servers. This method is effective in certain circumstances, including when you must ensure simultaneous availability of the standby instance while applying replicated changes (redo) at the remote site. If the features of Active Data Guard are not required, then it could be beneficial to consider an alternative using VMware and EMC solutions.

Figure 5: Alternative DR Setup



In this alternative architecture (as illustrated in Figure 5), you would virtualize the Oracle databases at the primary datacenter, and then use SAN replication technology (which may be an additional purchase) such as SRDF or RecoverPoint from EMC to replicate the block data from the primary storage system to the secondary storage system. This block data will include the application data, as well as the files that contain the virtual machines. The virtual machines will not be running on any servers at the secondary datacenter, nor will that storage be presented to any VM hosts. Since these virtual machines are neither installed nor running at the secondary site, no database license is required at that location.

Of course, in a disaster situation where you have to failover to the secondary site (bringing the virtual machines out of storage and causing the Oracle databases to be installed and running) then you would need to account for the licenses. Depending on your agreement with Oracle, this may be accomplished using the so-called 10-Day Rule, or by some other means. This architectural example has the potential to reduce your Oracle license footprint by 50% or more. The recovery of virtual machines at the secondary site can be accomplished using VMware's Site Recovery Manager (SRM). This is described in further detail in section 4.3.2.

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2.4.10 Storage Choices

While selection of storage technology does not directly affect the purchase or support cost of Oracle software, there are considerations that may apply. These are discussed generically for all RDBMS platforms within the various storage solutions outlined in this white paper. However, Oracle attempts to imply that there is a link here by introducing and referring to non-contractual policy documents and white papers with verbiage that could be interpreted to suggest the same. Again, with vSphere versions 5.1-5.5, Oracle has asserted that all computers attached to "shared storage" (implied SAN or NAS) must be licensed if any of them have Oracle software installed and/or running on them. As outlined previously, this is a non-contractually binding assertion. The application of this to your storage usage is discussed in detail under section 4.1.3 VSAN below.

2.4.11 Oracle Support

For Oracle products, support provides access to the latest patches and security fixes, technical support from Oracle, and license rights for newly released software versions. Support contracts are often grouped with license purchases, making it difficult to cancel support for specific products without canceling it for all products in the group.

Oracle has a support statement that specifies that all Oracle technologies are supported when running on VMware. This support statement can be found in My Oracle Support (MOS) document number 249212.1. In spite of occasional customer worries, House of Brick has found that the Oracle support organization is very responsive to support requests, even when it is clearly understood that the Oracle product is running in a VMware environment. We have encountered one or two instances where the level-1 support person pushed back, but a simple request to escalate to the duty manager has always resolved such resistance.

VMware Corporation provides an excellent service that is available to their customers running Oracle products on VMware. As described in VMware's Oracle Support Policy:

> "VMware Oracle Support provides customers the following new advantages as part of the existing Support and Subscription contract at no additional charge:
>
> - Total ownership of Oracle Database technical issues reported to VMware Support
> - Access to a team of Oracle DBA resources within VMware Support to troubleshoot related to Oracle
> - Databases used as a data store or run within a VM
> - Performance tuning and best practices related to Oracle Database used as a data store or run within a VM
> - Faster resolution of technical issues in VMware environments via a TSANet collaborative support arrangement between VMware Support and Oracle Support"

The entirety of VMware's Oracle Support Policy can be found at:
https://www.vmware.com/support/policies/oracle-support.

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2.4.12 Virtual Rights

The licenses are assigned to physical servers (virtual hosts) and can only be associated with one host at any given time. The total number of cores or sockets on servers with Oracle software "installed and/or running" must be accounted for and licensed. Licenses can be moved to a new server only when the original server is decommissioned or repurposed. The binding Oracle agreements are completely agnostic to VMware virtualization. There is no mention of VMware in any of these binding documents.

2.4.13 Hyper Threading

Oracle only requires you to license physical cores and not logical cores, or hyper-threads. In the case of Standard editions, sockets are licensed instead of cores.

2.5 Third-Party Licensing Considerations for vSphere

Often the biggest issues confronting the design of vSphere clusters is minimizing the amount of license and maintenance fees needed to run hardware-licensed workloads. Some vendors choose licensing schemes that consider the capabilities and resources of the underlying hardware rather than the specific virtual machine(s) on which the software is deployed. Oracle is a well-known example of hardware-licensed software where the licensing metrics are described in terms of physical hosts on which the software is either installed or running. If at any time a virtual machine runs (or can be demonstrated to have installed) Oracle software on a physical host, then that host must be appropriately licensed. Some basic strategies for managing this type of third party licensing are given below.

There are differing opinions on the topic of how to cluster these workloads within vSphere.

One school of thought is to build a separate cluster of vSphere hosts specifically for hardware-licensed workloads. This is a common approach for customers to take because it offers the least risk of software running on unlicensed hardware. But this can significantly increase the cost of licensing, particularly when considering performance and N+1 host redundancy. Fortunately, at least in the case of Oracle, applying this model is unnecessary if its only purpose is for license compliance.

Another school of thought is to build larger vSphere clusters and run different types of workloads within that cluster – app server, web server, database (MySQL, SQL Server, Oracle), etc. This model is not necessarily the best practice at House of Brick because of the cost of underutilized processors that have been licensed for software that the particular host is not dedicated to running. Putting disparate workloads on the same host does not maximize the license investment of any one of those workloads. When we pay for licensing cores on a single host, we want those cores to be devoted to running only that software. As such, managing host-specific licensing in environments where virtual workloads can be moved seamlessly between cluster hosts must be approached with care. However, virtual machines can be reliably isolated to a subset of the cluster's hosts using a combination of operational procedures and configuration of vSphere automated features, such as DRS and HA. The procedures for doing this using host affinity and anti-affinity rules are outlined in Appendices A and B. Further, by querying the VMware vCenter database as described in this VMware Technology Network blog post, it is possible to determine which virtual machines have run on which vSphere hosts. With proper procedures, configuration, and auditing, customers can run this model with the confidence that they are maintaining compliance with their licensing terms.

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Microsoft licensing practices are generally friendlier to virtualization if an active support contract is maintained. However, recent changes are leaning toward the type of model described in this section, particularly when support is not maintained.

We encourage customers to read and understand their software licensing agreements. We also encourage them to operate within their agreements. House of Brick can provide assistance and guidance to that end.

2.5.1 Oracle Licensing Strategies

To assist with reducing licensing costs, a different edition may be used for development and test than is used for production. However if this is the case, we recommend that there should be at least one test environment (usually QA or UAT) that is the same edition as production (see Section 2.4.8 Oracle Editions – Enterprise vs. Standard). With the effective isolation of virtual machines in a VMware environment, we routinely recommend that our customers run development and test instances on hosts shared with production. Many years ago, this would have been unthinkable, but VMware virtualization has made this possible with no threat of noisy neighbor performance intrusion when configured properly. It is House of Brick's best practice to use VMware Resource Pools to give priority to production workloads in this scenario. Once a host is licensed for Oracle technology, we can run as many virtual machines running the Oracle software as will fit on that host without incurring any additional license cost.

The goal is to pay Oracle only for what you actually use and owe according to the contract. House of Brick has several strategies to help minimize the licensing cost for a given scenario. Refer to "Third-Party Licensing Considerations" above for an overview.

It is exceptional to find workloads today where Named User Plus (NUP) still plays a cost-effective role in Oracle licensing on VMware. Small or medium businesses may be an example where this could apply. However for most enterprises, the most cost-effective licensing practice is to license all Oracle products running on VMware using the processor licensing metric. For environments where NUP may still be financially appropriate, NUP requires that every person or device using the system have a name that can be documented and accounted for. Multiplexing devices or sharing login credentials among multiple individuals will not eliminate the burden to identify end users in the NUP metric.

With Standard, Standard One or Standard 2 Editions, which count sockets rather than cores, you should purchase chips with the maximum core-count per socket up to the 16-core limit mentioned above.

Know and understand the Oracle licensing documents. There are many myths in circulation and we find that some customers may have overpaid for Oracle license purchases or support renewals because they were unaware of the details of their agreements. The bottom line is that you are obligated only by what is specifically in the contract that you execute with Oracle.

2.5.1.1 Soft Partitioning Server Cores Using VMware CPU Affinity

The vSphere Resource Management Guides for ESXi 5.5 and ESXi 6.0 contain a detailed description of core affinity configuration under the heading 'Using CPU Affinity'. Although the technical description and caveats have not changed, VMware is now showing a new willingness and approach with respect to this feature. In House of Brick's September 17, 2014 and January 17, 2016 blog posts, we asked that VMware Engineering make a definitive statement with respect to the precision with which assigned core boundaries are maintained.

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According to Don Sullivan, VMware Cloud Platform Business Unit Product Line Marketing Manager for Business Critical Applications and Database Specialist Solution Architect, VMware is now making an unambiguous, declarative statement that CPU affinity exactly respects assigned core boundaries and has done so in previous versions. Don reports that the statement has the solid backing of VMware Engineering and VMware Corporation as a whole.

By using CPU Affinity, and by applying the Oracle agreement principles of licensing all processors where Oracle is installed and/or running, you can effectively license only those cores in a server that are actually required for a particular workload, instead of licensing all of the cores. There are tradeoffs and implications in doing this, so we encourage a careful study of the CPU affinity considerations described in section 4.1.4 of this paper, and as published in the vSphere Resource Management Guide. The House of Brick blog posts cited above can also be reviewed.

ESXi CPU-affinity restricts the Virtual machine processing and therefore any and all software running within that VM to the respective cores assigned to the VM. The VM is isolated to running on those assigned cores and therefore the Oracle software only needs to be licensed for that subset.

2.5.1.2 Limiting Cores Through Socket Disabling

In addition to using VMware to pin virtual machines to licensed cores in a single server, another method for limiting the core count that must be licensed for Oracle is through socket or core disabling. If you have a two-socket server, for example, you can disable one of those sockets in the BIOS settings of that server. You then only have to license the number of cores on the single chip in the remaining active socket.

2.5.1.3 More Information Online

In addition to this white paper, there are some important sources of information online for cutting through the volumes of misinformation that you may be exposed to regarding licensing Oracle technology on VMware and EMC solutions.

House of Brick Blogs and Support Pages
http://houseofbrick.com/?s=oracle+license

Don Sullivan's VMware Blog "The Definitive Collateral Discussion
http://blogs.vmware.com/vsphere/2015/04/oracle-licensing-discussion-definitive-collateral-collection.html

Everything Oracle at EMC
https://community.emc.com/community/connect/everything_oracle?cmp=pac-oow_2011-print_showdailypub

Straight Talk on Oracle on VMware Licensing Webinar @ Database Trends and Applications
http://www.dbta.com/Webinars/722-Straight-Talk-on-Oracle-on-VMware-Licensing.htm

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3 RDBMS Licensing for EMC Hardware

3.1 Compute Selection

Most fee-based RDBMS software offers one or more options for licensing based on the power or capabilities of the hardware. The primary metrics used are quantity of memory and/or number of CPUs. When it comes to counting CPUs, most use a processing core as the base metric without regard for socket or core-count configurations. A notable exception is Oracle Standard editions, which are licensed by socket. For Standard editions, Microsoft has recently started restricting its software to utilize a maximum of 16 cores. Similarly, Oracle has restricted its SE2 to utilize a maximum of 16 user threads. Refer to RDBMS Licensing Basics is section 2 of this document for more details specific to popular RDBMS vendors.

When selecting hardware (servers, blades, or appliances) it is important to understand what restrictions apply and how those restrictions will impact the cost and feasibility of licensing.

3.1.1 Processor/Socket Counts

Although it should be simple enough to count processors, this has become a much-debated topic since it is the primary metric that determines licensing cost and vendors obviously want to maximize their revenue.

3.1.1.1 Assumptions

For purposes of this section we need to make some base assumptions that may or may not apply to any particular vendor, but are typical for RDBMS products currently available. As always, check the terms and/or seek credible counsel for any particular product you are evaluating.

- The terms "server", "blade", and "node" are interchangeable for licensing purposes.
- In virtual infrastructures, a "server", "blade" or "node" may be used as a vSphere host.
- Clustering does not require all nodes within a cluster to be licensed – despite claims by Oracle to the contrary. See section 2, RDBMS Licensing Basics, for details.
- In general, all populated and enabled sockets within a physical server, and physical cores on which the RDBMS is running, must be considered for licensing.
- In converged architectures, such as Vblock, compute nodes may be licensed independent of each other.
- In hyper-converged architectures, such as VxRack, nodes within an "enclosure" that look like servers or blades from an operational standpoint may be licensed independently.
- In hyper-converged architectures, such as VxRail, nodes within an "appliance" that look like servers or blades from an operational standpoint may be licensed independently.
- A vacant socket does not need to be licensed, but may be considered when restrictions apply to a server's "capacity". (e.g.: Oracle Standard Edition 2 cannot be used on a server with a *capacity* of more than two sockets – regardless of how many are populated or enabled.)

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- A socket disabled in BIOS does not need to be licensed, as discussed in the previous section.

3.1.2 RDBMS Hardware Licensing Examples

House of Brick provides these examples based on spreadsheet calculations using a custom tool that we developed. A calculation of zero dollars ($0) or a blank cell in the results columns indicates an invalid configuration for licensing of the selected products.

3.1.2.1 Processor Based Licensing

Processor based licensing shows pricing solely on the number of processors present in the corresponding hardware. This price typically licenses the hardware for an unlimited number of users.

The "Minimum Config" columns assume that the corresponding hardware has the minimum number of CPU sockets populated or enabled. This is also assumed to be the configuration and licensing increment. The "Maximum Config" columns show pricing with all processor sockets populated and enabled.

3.1.2.2 User/CAL Based Licensing

User/CAL based licensing shows pricing for a given number of identifiable users (or devices). This is the equivalent of Named User Plus for Oracle and Server + CAL for Microsoft. The price licenses the hardware to be used by the specified number of users or devices.

The "Minimum Config" columns assume that the corresponding hardware has the minimum number of CPU sockets populated or enabled. This is also assumed to be the configuration and licensing increment. The "Maximum Config" columns show pricing with all processor sockets populated and enabled along with any corresponding minimum per server or per processor requirements.

3.1.3 Licensing Matrix – Oracle Enterprise

Oracle Enterprise Edition can be licensed for either processors or named users as shown in the following matrix. Pricing is shown for selected hardware and reflects a 25% discount off of list, which is reasonably available:

Figure 6: Oracle Enterprise Licensing Matrix

				Processor Based Licensing					User/CAL Based Licensing					
				Core	Minimum Config & Increment		Maximum Config		Minimum Config & Unit Increment			Maximum Config, Minimum Users		
Software	Edition	Discount	Hardware	Factor	Purchase	Maintenance	Purchase	Maintenance	Purchase	Maintenance	Users	Purchase	Maintenance	Users
Oracle	Enterprise	25.0%	VxRail 60 Appliance	0.50	$427,500	$94,050	$6,840,000	$1,504,800	$213,750	$47,025	300	$3,420,000	$752,400	4,800
			VxRail 120 Appliance	0.50	$855,000	$188,100	$13,680,000	$3,009,600	$427,500	$94,050	600	$6,840,000	$1,504,800	9,600
"Appliance" reflects licensing all nodes			VxRail 160 Appliance	0.50	$1,140,000	$250,800	$18,240,000	$4,012,800	$570,000	$125,400	800	$9,120,000	$2,006,400	12,800
"Enclosure" reflects licensing all nodes			VxRail 200 Appliance	0.50	$1,425,000	$313,500	$22,800,000	$5,016,000	$712,500	$156,750	1,000	$11,400,000	$2,508,000	16,000
See individual node pricing below			VxRack HYP-0001 Enclosure	0.50	$1,710,000	$376,200	$1,710,000	$376,200	$855,000	$188,100	1,200	$855,000	$188,100	1,200
			VxRack HYP-0002 Enclosure	0.50	$1,710,000	$376,200	$1,710,000	$376,200	$855,000	$188,100	1,200	$855,000	$188,100	1,200
			VxRack HYP-0003 Enclosure	0.50	$1,710,000	$376,200	$1,710,000	$376,200	$855,000	$188,100	1,200	$855,000	$188,100	1,200
			VxRack HYP-0004 Enclosure	0.50	$1,425,000	$313,500	$1,425,000	$313,500	$712,500	$156,750	1,000	$712,500	$156,750	1,000
			VxRack HYP-0005 Enclosure	0.50	$1,710,000	$376,200	$1,710,000	$376,200	$855,000	$188,100	1,200	$855,000	$188,100	1,200
			VxRack HYP-0006 Enclosure	0.50	$1,425,000	$313,500	$1,425,000	$313,500	$712,500	$156,750	1,000	$712,500	$156,750	1,000
			VxRail 60 (1x6) Node	0.50	$106,875	$23,513	$106,875	$23,513	$53,438	$11,756	75	$53,438	$11,756	75
			VxRail 120 (2x6) Node	0.50	$213,750	$47,025	$213,750	$47,025	$106,875	$23,513	150	$106,875	$23,513	150
			VxRail 160 (2x8) Node	0.50	$285,000	$62,700	$285,000	$62,700	$142,500	$31,350	200	$142,500	$31,350	200
			VxRail 200 (2x10) Node	0.50	$356,250	$78,375	$356,250	$78,375	$178,125	$39,188	250	$178,125	$39,188	250
			VxRack HYP-0001 (2x12) Node	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
			VxRack HYP-0002 (2x12) Node	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
			VxRack HYP-0003 (2x12) Node	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
			VxRack HYP-0004 (2x10) Node	0.50	$356,250	$78,375	$356,250	$78,375	$178,125	$39,188	250	$178,125	$39,188	250
			VxRack HYP-0005 (2x12) Node	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
			VxRack HYP-0006 (2x10) Node	0.50	$356,250	$78,375	$356,250	$78,375	$178,125	$39,188	250	$178,125	$39,188	250
			VxRack HYP-0007 (2x10) Server	0.50	$356,250	$78,375	$356,250	$78,375	$178,125	$39,188	250	$178,125	$39,188	250
			VxRack HYP-0008 (2x12) Server	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
			VxRack HYP-0009 (2x10) Server	0.50	$356,250	$78,375	$356,250	$78,375	$178,125	$39,188	250	$178,125	$39,188	250
			VxRack HYP-0010 (2x10) Server	0.50	$356,250	$78,375	$356,250	$78,375	$178,125	$39,188	250	$178,125	$39,188	250
			VxRack HYP-0011 (2x12) Server	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
			VxRack HYP-0012 (2x12) Server	0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300

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NOTE: The terms "Appliance" and "Enclosure" reflect the licensing of all nodes within the corresponding unit. It is legitimate to license a subset of nodes within an appliance or enclosure, and where applicable, individual node or server pricing is shown lower in the chart.

For example the range of core configurations shown for the VxRail 60 APPLIANCE (licensing all 4 nodes in each enclosure) is 24 cores per enclosure up to 384 cores for the maximum of 16 enclosures in the fully-populated appliance as shown. When licensing an individual VxRail 60 NODE there are only 6 cores to consider.

3.1.4 Licensing Matrix – Microsoft SQL Server Enterprise

Microsoft Enterprise Edition can only be licensed for processors. There are no licensing restrictions on the amount of memory or the number of CPU cores. Pricing is shown for selected hardware:

Figure 7: SQL Server Enterprise Licensing Matrix

				Processor Based Licensing					User/CAL Based Licensing					
				Core	Minimum Config & Increment		Maximum Config		Minimum Config & Unit Increment			Maximum Config, Minimum Users		
Software	Edition	Discount	Hardware	Factor	Purchase	Maintenance	Purchase	Maintenance	Purchase	Maintenance	Users	Purchase	Maintenance	Users
Microsoft	Enterprise	25.0%	VxRail 60 Appliance	1.00	$128,304	$37,208	$2,052,864	$595,331						
			VxRail 120 Appliance	1.00	$256,608	$74,416	$4,105,728	$1,190,661						
"Appliance" reflects licensing all nodes			VxRail 160 Appliance	1.00	$342,144	$99,222	$5,474,304	$1,587,548						
"Enclosure" reflects licensing all nodes			VxRail 200 Appliance	1.00	$427,680	$124,027	$6,842,880	$1,984,435						
See individual node pricing below			VxRack HYP-0001 Enclosure	1.00	$513,216	$148,833	$513,216	$148,833						
			VxRack HYP-0002 Enclosure	1.00	$513,216	$148,833	$513,216	$148,833						
			VxRack HYP-0003 Enclosure	1.00	$513,216	$148,833	$513,216	$148,833						
			VxRack HYP-0004 Enclosure	1.00	$427,680	$124,027	$427,680	$124,027						
			VxRack HYP-0005 Enclosure	1.00	$513,216	$148,833	$513,216	$148,833						
			VxRack HYP-0006 Enclosure	1.00	$427,680	$124,027	$427,680	$124,027						
			VxRail 60 (1x6) Node	1.00	$32,076	$9,302	$32,076	$9,302						
			VxRail 120 (2x6) Node	1.00	$64,152	$18,604	$64,152	$18,604						
			VxRail 160 (2x8) Node	1.00	$85,536	$24,805	$85,536	$24,805						
			VxRail 200 (2x10) Node	1.00	$106,920	$31,007	$106,920	$31,007						
			VxRack HYP-0001 (2x12) Node	1.00	$128,304	$37,208	$128,304	$37,208						
			VxRack HYP-0002 (2x12) Node	1.00	$128,304	$37,208	$128,304	$37,208						
			VxRack HYP-0003 (2x12) Node	1.00	$128,304	$37,208	$128,304	$37,208						
			VxRack HYP-0004 (2x10) Node	1.00	$106,920	$31,007	$106,920	$31,007						
			VxRack HYP-0005 (2x12) Node	1.00	$128,304	$37,208	$128,304	$37,208						
			VxRack HYP-0006 (2x10) Node	1.00	$106,920	$31,007	$106,920	$31,007						
			VxRack HYP-0007 (2x10) Server	1.00	$106,920	$31,007	$106,920	$31,007						
			VxRack HYP-0008 (2x12) Server	1.00	$128,304	$37,208	$128,304	$37,208						
			VxRack HYP-0009 (2x10) Server	1.00	$106,920	$31,007	$106,920	$31,007						
			VxRack HYP-0010 (2x10) Server	1.00	$106,920	$31,007	$106,920	$31,007						
			VxRack HYP-0011 (2x12) Server	1.00	$128,304	$37,208	$128,304	$37,208						
			VxRack HYP-0012 (2x12) Server	1.00	$128,304	$37,208	$128,304	$37,208						

NOTE: The terms "Appliance" and "Enclosure" reflect the licensing of all nodes within the corresponding unit. It is legitimate to license a subset of nodes within an appliance or enclosure, and where applicable, individual node or server pricing is shown lower in the chart.

For example the range of core configurations shown for the VxRail 60 *APPLIANCE* (licensing all 4 nodes in each enclosure) is 24 cores per enclosure up to 384 cores for the maximum of 16 enclosures in the fully-populated appliance as shown. When licensing an individual VxRail 60 *NODE* there are only 6 cores to consider.

3.1.5 Licensing Matrix – License Cost Comparison

With the calculator, you can also compare the cost to license different databases on various platforms, including the converged and hyper converged platforms from EMC described later in this section:

Figure 8: Compare RDBMS Costs Across Platforms

						Processor Based Licensing					User/CAL Based Licensing					
						Core	Minimum Config & Increment		Maximum Config		Minimum Config & Unit Increment			Maximum Config, Minimum Users		
Software	Edition	Discount	Hardware	Hardware		Factor	Purchase	Maintenance	Purchase	Maintenance	Purchase	Maintenance	Users	Purchase	Maintenance	Users
Oracle	Enterprise	25.0%	VxRack HYP-0008 (2x12)	VxRack HYP-0008 (2x12) Server		0.50	$427,500	$94,050	$427,500	$94,050	$213,750	$47,025	300	$213,750	$47,025	300
Microsoft	Enterprise	25.0%	VxRail 160 (2x8)	VxRail 160 (2x8) Node		1.00	$85,536	$24,805	$85,536	$24,805						
Microsoft	Enterprise	25.0%	VxRail 60	VxRail 60 Appliance		1.00	$128,304	$37,208	$2,052,864	$595,331						
Microsoft	Standard	25.0%	VxRail 60	VxRail 60 Appliance							$1,557	$452	4	$1,557	$452	4
Microsoft	Business Intel	25.0%	VxRail 60	VxRail 60 Appliance		1.00					$9,219	$2,674	4	$9,219	$2,674	4
			"Appliance" reflects licensing all nodes "Enclosure" reflects licensing all nodes See comparable "Node" or "Server" for minimum license													

To access the comparison features, you can download the calculator here.

3.2 Storage Selection

In general, the selection of storage does not have a direct impact on licensing RDBMS software. However, there can be an indirect link as explained in this blog post by Nathan Biggs, CEO at House of Brick.

In a nutshell, the efficiency and performance of storage has a direct impact on throughput and query response times of an RDBMS, since storage is usually the slowest operation involved. For this reason, faster storage can correspond to higher CPU utilization, causing organizations to assume they are CPU bound and driving them to purchase additional processing power when they may, or may not, actually need it. The higher CPU utilization is a direct indicator of increased throughput and sub-millisecond latencies. A service level agreement or application throughput metric should be the indicator for determining when more CPU, and thus additional RDBMS licensing, is required.

The various technologies described below can increase performance of your storage. When evaluating the need to increase processor core counts, be sure to consider throughput requirements and not just processor utilization metrics. In other words, if faster storage drives higher CPU, don't assume to add processors and increase your license cost without a business justification to do so.

3.2.1 Assumptions

For purposes of this section, we need to make some base assumptions that may or may not apply to any particular vendor, but are typical for RDBMS products currently available. As always, check the terms and/or seek credible counsel for any particular product you are evaluating.

- The mere presence of a vendor's software on any storage volume does not constitute "installed" – despite claims by some vendors to the contrary. See section 2, RDBMS Licensing Basics, for more information. For example, a shared LUN containing Oracle software would also have to be presented via a mounted file system to be accessed. Even at that, a VMDK storage device containing Oracle software cannot be accessed by more than one ESX host at a time without setting the multi-writer flag.

3.2.2 Fully Automated Storage Tiering (FAST) Cache

FAST Cache uses Flash drives to improve the performance of storage pools. FAST Cache accelerates performance by placing data sent to the array or outgoing from spinning drives (SAS and NL-SAS) on flash drives so that subsequent accesses will be provided at sub-millisecond latencies. For example, storage and database administrators can collaborate to ensure database storage pools are using FAST Cache. Databases using FAST Cache will have storage lower latencies and overall better performance.

3.2.2.1 Without FAST Cache

- Database storage design will be complex as the storage and database administrators would have to manually design an optimized database layout on different tiers of disk (flash, SAS, NL-SAS)
- The database administrator will question if storage is responsible for performance issues

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3.2.2.2 With FAST Cache

- Storage performance is automated
- Storage performance is continuously optimized as data access patterns change
- FAST Cache can be personalized to accelerate mission critical workloads
- Database storage configuration is simplified

3.2.3 Fully Automated Storage Tiering for Virtual Pools (FAST VP)

EMC's (FAST VP) is an algorithm that monitors data within block and file resources and automatically relocates them to an appropriate storage tier. FAST leverages the performance of Flash media to optimize workloads with spinning disks. For instance, data that is being accessed frequently will be placed on the best performing tier (Flash), while data that is rarely accessed is relocated to high capacity tiers. Using FAST VP policies customers can specify where the initial data is placed (ex. Highest tier, lowest tier) and as the data is accessed FAST VP will relocate data across the tiers based on usage. Other storage vendors provide this capability, with varying degrees of effectiveness in our experience. The feature itself does not have any direct licensing implications.

3.2.3.1 Without FAST VP

- In the absence of FAST VP or a similar algorithm, proactive placement of data may be required to achieve the best RDBMS performance. This can be tedious and cumbersome depending on the storage technology implemented and RDBMS capabilities for relocation.
- vSphere provides storage vMotion, which can facilitate manual management of VMDKs and place them on appropriately performing datastores.

3.2.3.2 With FAST VP

- In a mixed tier environment, dynamic storage relocation can ensure that only the portions of a database that warrant flash, end up on flash.
- Automates relocation at a granular level (i.e. storage extent group level /256MB) based on access patterns.
- Reduced management overhead—generally users can set it and forget it.
- May require a "burn-in" period to learn workload patterns for new volumes.
- We have found that it may still be beneficial to put redo on their own volume since those blocks as a whole will have a very different access pattern compared to the data and index blocks.

3.2.4 All-Flash / XtremIO

As the price of all flash storage solutions has dropped, we are starting to see storage infrastructures that no longer include any spinning disk. This reduces complexity as well as eliminates licensing of proprietary dynamic relocation algorithms.

Again, there is no direct correlation between the use of all-flash storage and the cost of your RDBMS license. However, be aware that in many cases you may see higher CPU usage corresponding to greater throughput and sub-millisecond latencies in your applications. We

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have seen application stacks with apparent logical bottlenecks (i.e. multiple users needing to update the same row at the same time). In these situations, transaction throughput was benchmarked on identical systems, but with different underlying storage performance quality. Faster storage did nothing to improve throughput even though CPU was nowhere near fully utilized.

3.2.5 VMAX3

The VMAX All Flash arrays (VMAX 450F and 850F) take advantage of the latest, most cost-efficient 3D NAND flash drive technology. In addition, the VMAX All Flash features multi-dimensional scale, large write-cache buffering, back-end write aggregation, high density IOPS, high bandwidth, and low latency. IT Organizations can easily scale-out using V-Bricks that are comprised of 53 TBu (Terabytes usable) of capacity. Here are the features that benefit databases:

- Large dynamic random-access memory (DRAM) based cache enables all writes, including Oracle log writes or batch loads, to be buffered. Writes using the DRAM based cache are faster than flash drives.
- The write folding feature means that the VMAX cache only commits the latest changes from cache to SSD media periodically. Performance is optimized as all writes are cached but only the most recent changes are sent to the flash drives. Write folding also lengthens the life of flash drives.

The FlashBoost feature optimizes performance of "read-misses" by sending small-block reads directly from the back-end flash drives to the front-end ports. Then the read data is staged in the DRAM based cache for future access. As far as the licensing impact of your VMAX3 on RDBMS software, the concerns are the same as with any enterprise storage array as discussed throughout this section.

3.2.6 ScaleIO

ScaleIO is software that creates a server-based SAN from local server storage. It converges storage, networking, and compute resources of commodity server hardware into a single-layer storage architecture. Using ScaleIO the HDDs, SDDs, and PCI flash cards in servers can be combined into pools of block storage with varying tiers of performance. ScaleIO is enterprise storage and provides data protection, multi-tenant capabilities, and add-on enterprise features like Quality of Service (QoS), thin provisioning, and snapshots. The following ScaleIO features are beneficial for databases:

- Massive scalability in that ScaleIO can start with as little as three nodes and grow to thousands of nodes. As capacity and performance requirements increase additional storage and compute resources can be added modularly.
- Extreme performance is achieved through using server in a ScaleIO cluster for processing of I/O operations. Massive I/O parallelism eliminates bottlenecks and provides greater throughput and IOPS at scale.
- Elasticity is the ability of ScaleIO to reconfigure itself as compute resources increase or decrease. The system automatically rebalances data "on the fly" with no downtime.

Like VSAN, ScaleIO is a storage presentation and abstraction layer. The RDBMS licensing implications for servers using this technology are, therefore, the same as discussed in the VSAN section, 4.1.3, below.

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3.3 Converged Architectures

Converged architectures are ones that typically integrate infrastructure components into pre-built racks or enclosures. Components typically include compute, storage and network.

- RDBMS licensing will usually only be affected by the choice of compute (typically only CPU).
- Compute components are usually either rack servers or blades.
- Sometimes there will be a variety of storage choices. Refer to previous sections for information about how various storage options might affect RDBMS licensing.
- To date, networking does not have a direct impact on RDBMS licensing.

3.3.1 Vblock/VxBlock

Two examples of converged architecture are the EMC/VCE Vblock and VxBlocks, which make use of one or more blade chassis populated with various blade server options.

While both the Vblock and the VxBlock use Cisco Nexus 9000 Switches for core networking, the VxBlock factory integrates NSX, VMware's SDN technology.

For RDBMS licensing implications of the various blades, refer to standard Intel server types with corresponding CPU socket and core combinations.

Refer to previous sections for information about the RDBMS licensing impact of the various storage options.

Refer to the previous sections entitled "Licensing Matrix – {vendor}", or you can download the calculator here for example licensing models and costs.

3.4 Hyper-Converged Architectures

Hyper-converged architectures are ones that typically integrate infrastructure components into appliances that include compute, storage and network in a small footprint. They can be integrated into existing server racks and grow modularly by adding more appliances.

- Due to a large numbers of sockets, it may not be possible to run software with host socket limitations (Standard Edition) unless the software can be restricted to nodes within the appliance.
- Generally same storage considerations as Converged Architectures (above).

3.4.1 VxRack

VxRack is the next generation of EMC Hyper -Converged architecture. It incorporates the latest storage technologies and software-defined datacenter capabilities.

The available compute components are called enclosures. These enclosures are shipped with fully populated processor sockets. There are three types of enclosures:

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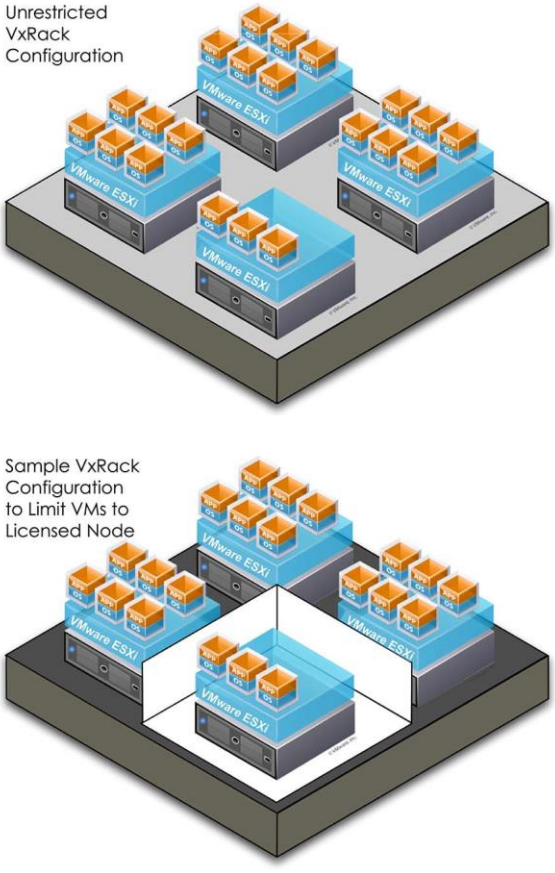
- Dense Compute enclosures, which look very similar to VxRail enclosures (discussed below).
  - These enclosures include four "nodes" of compute power with each node looking like a separate blade.
  - Each node acts like a SAN controller, providing access to six attached physical disk drives that will be pooled into the total storage for the system via ScaleIO.
  - In addition to providing access to the storage, each node can be used as an independent server or vSphere host and would need to be licensed for any RDBMS software.
- Dense Storage enclosures look like traditional rack servers with internal storage.
  - There is a single compute node, but the storage capacity is dramatically increased compared to a compute enclosure.
  - The compute node acts like a SAN controller, providing access to all attached physical disk drives that will be pooled into the total storage for the system via ScaleIO.
  - In addition to providing access to the storage, the compute node can be used as an independent server or vSphere host.
- Storage-only enclosures maximize storage capacity.
  - There is a compute node, but it is reserved for the purpose of providing ScaleIO access to the storage. It cannot be used independently or as a vSphere host.
  - Licensing of RDBMS software does not apply to these enclosures since they are incapable of running application software.

Figure 9: VxRack Configurations



The illustration to the right shows the concept of configuring a VxRack so that all of the virtual machines stay on licensed nodes. In this example, there is one node that is licensed, and so we at House of Brick restrict the VMs to only run on that node. The smallest unit that can be licensed for RDBMS software will typically be a single compute node. VxRack nodes have two sockets containing either 10 or 12 cores each for a total of 20 or 24 cores per node/enclosure.

Refer to the sections 4.1.3 VSAN and 3.3.4 ScaleIO for information about the RDBMS licensing impact of the ScaleIO storage used in this architecture.

Refer to the Appendices on configuring host affinity and anti-affinity rules to restrict workloads to run only on licensed hosts.

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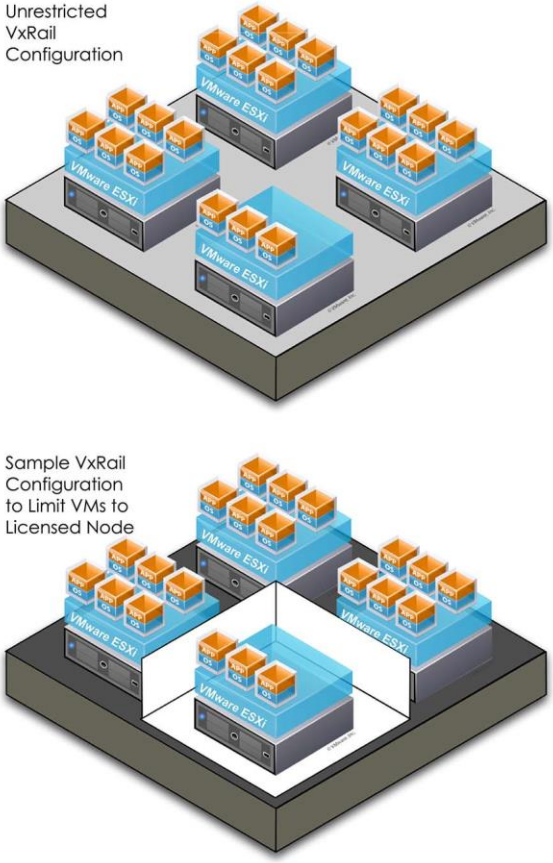
Refer to the previous sections entitled "Licensing Matrix – {vendor}", or you can download the calculator here for example licensing models and costs.

3.4.2 VxRail

The VxRail 3.5 appliances consist of four compute nodes and an array of hard drives in a two rack-unit (2U) enclosure. Each node has either one or two sockets and each appliance, therefore, contains either four or eight sockets. Appliances can have up to 512GB of memory and are shipped with CPU fully populated. Up to 16 appliances can be combined by connecting them to a shared networking infrastructure for a maximum of 1,280 CPU cores across 64 compute nodes with a combined total of up to 8TB of memory and 384TB of raw storage.

The illustration to the right shows the concept of configuring a VxRail so that all of the virtual machines stay on licensed nodes. In this example, there is one node that is licensed, and so we at House of Brick restrict the VMs to only run on that node. You may designate one of the non-licensed nodes and use the 10-day rule to vMotion to it for maintenance or any other reason.

Figure 10: VxRail Configurations



The smallest unit that can be licensed for RDBMS software will typically be a single compute node with either one or two sockets depending on appliance model. The VxRail 60 node has a single socket with six cores. Whereas the VxRail 200 node has two sockets with 10 cores each for a total of 20.

Refer to the sections 4.1.3 VSAN and 3.2.6 ScaleIO for information about the RDBMS licensing impact of the VSAN storage used in this architecture.

Refer to the Appendices on configuring host affinity and anti-affinity rules to restrict workloads to run only on licensed hosts, and be aware that tools such as VxRail Manager may vMotion VMs in response to maintenance requests. As long as such tools honor DRS [anti-]affinity rules and those rules reflect your licensing, then you will remain in compliance.

Refer to the previous sections entitled "Licensing Matrix – {vendor}", or you can download the calculator here for example licensing models and costs.

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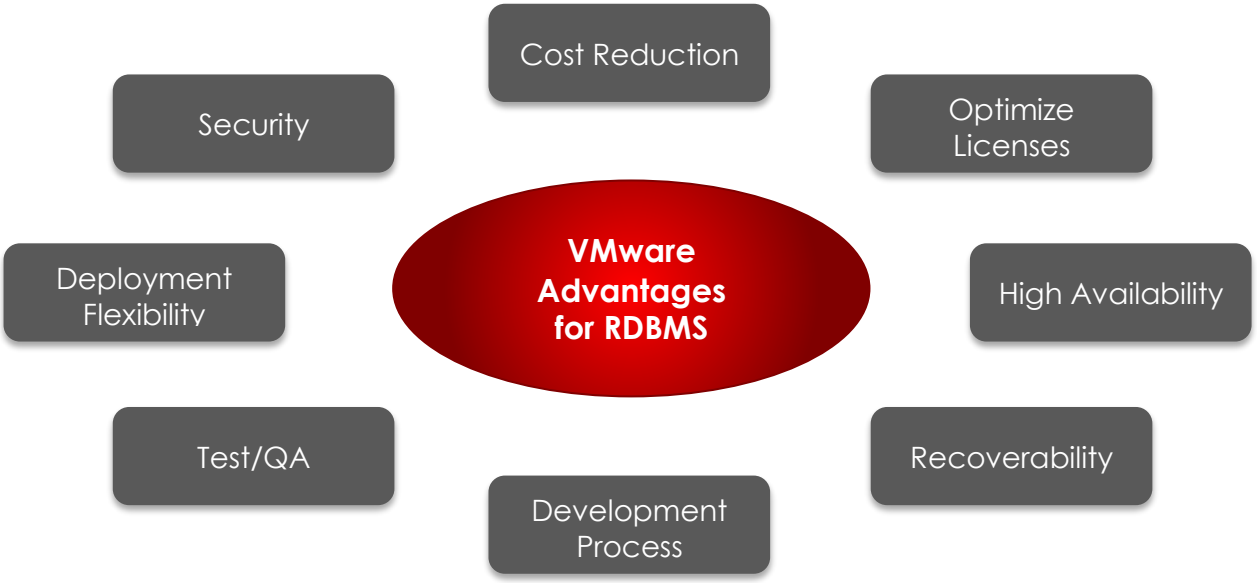
4 RDBMS Licensing for VMware and EMC Features

4.1 VMware is the Best Choice for Database Infrastructure

Since 1998, House of Brick has been focused on performance, scalability, and operational excellence for business/mission-critical systems. These systems typically operate with an underlying relational database. When we first discovered VMware virtualization, we quickly realized the power of encapsulating the whole application stack. VMware became, not only our preferred virtualization environment, but also our preferred platform for critical applications - period.

Some of the advantages of virtualizing your RDBMS on VMware include:

Figure 11: Advantages of VMware for RDBMS



1. **Cost Reduction** - While most, if not all, of the remaining advantages also contain potential for cost savings, this deserves a mention of its own. Direct cost reductions come in the form of server consolidation, and operational efficiencies that are not available otherwise.
2. **Optimize Licenses** - Oracle and SQL Server are two prime examples of RDBMS products that license according to underlying hardware specifications. By optimizing the hardware, we are able to reduce the license footprint, while still gaining the other advantages listed here.
3. **High Availability** - HA solutions for Oracle and SQL Server databases are complex, costly, difficult to maintain, or altogether non-existent. VMware provides a lower cost, yet highly effective HA solution that is optimal for many workloads.
4. **Recoverability** - If your DR solution is for the database only, you are missing out on DR coverage for the rest of the application stack required to make that database work. VMware encapsulates the application stack and, when coupled with proper configuration and testing of replication, provides as close to perfect recoverability as any solution can get.

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5. **Development Process** - Developers need systems and data that are like production in every way passible. When they get quick access to production-like development environments, development time is reduced, and features are more robust on release.
6. **Test/QA** - The optimum environment to test on is production itself. That can be risky, however, since the production system needs to keep your organization running. VMware allows you to provide an exact copy of the production environment to the Test/QA team without impacting your critical systems.
7. **Deployment Flexibility** - Do you want to move your database workload from one licensed server to another? Do you want the advantages of a private, hybrid, or public cloud environment? Do you want to create live datacenters that are thousands of miles apart, and be able to swing back and forth between them? VMware virtualization, coupled with stretch storage solutions from EMC can facilitate these options.
8. **Security** - Not only does VMware create a minimalized attack profile with its small footprint hypervisor, but also advanced security features like Trusted Execution Technology from Intel allow virtual machines to validate security down to the chip level.

The following sections outline specific VMware/EMC features and their impact on database licensing.

4.1.1 VMware High Availability (vSphere HA)

This feature is included in all versions of vSphere except "Essentials", and it is automatically activated through vCenter when a host is added to a cluster. It provides the ability for running VMs to be automatically restarted on another host within the cluster in the event of a host failure. HoB recommends enabling vSphere HA for all business critical application clusters. In vSphere4 and above, the HA agents on the individual hosts can coordinate HA status and migrations without interacting with vCenter. For that reason, it is an accepted best practice to run vCenter Server as a VM within a vSphere HA cluster.

> **NOTE 1:** When vCenter Server is running within a VM, a scenario can occur where vSphere is "offline". In that case, use the vSphere client to connect directly to one of the cluster hosts to manage and/or restart the vCenter server VM.
>
> **NOTE 2:** By default, vSphere HA does not honor cluster DRS rules. This can be problematic when it comes to maintaining license compliance for VMs protected by vSphere HA. Refer to Appendix A - Host Affinity Rules for more information.

4.1.2 vSphere Distributed Resource Scheduler (DRS)

DRS is a feature included in the Enterprise Plus versions of vSphere that balances the needs of virtual machines in a cluster of server hosts. It is also used by VMware tools such as VxRail Manager. Among other things, it can balance capacity within a cluster, ensure that critical workloads have adequate resources, and allow for disruption-free server maintenance. This section discusses the use of DRS for business/mission-critical RDBMS systems.

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4.1.2.1 Partially Automated/Manual

Due to the variable nature of database workloads, it is generally not desirable to allow vSphere/DRS to relocate *production* databases automatically. Instead, we want human intervention, planning and monitoring for the location of business critical database workloads. Therefore, we do not recommend enabling fully automated DRS. Instead, we recommend setting it to Partially Automated, which allows VMware to recommend a location for the guest, but does not attempt to move it automatically.

This recommendation only applies to business critical database workloads and is one of the main reasons we recommend separating applications and database clusters whenever feasible.

4.1.2.2 Affinity Rules

Affinity rules in VMware are designed to configure virtual machines to run on specific physical hosts. This can be necessary for a variety of reasons, but it is especially useful as a tool to assist with license compliance in cases where the entire cluster is not licensed. Affinity rules can be useful when only a subset of hosts in the cluster are licensed, or to ensure that when new hosts are added there is a safety check to avoid being out of compliance. If a licensed VM migrates to a non-licensed vSphere host, then that could constitute an out-of-compliance situation.

Therefore, it is recommended to set host affinity rules for all VMs where host-specific licensing concerns apply. Rules should assign VMs to normally run on licensed hosts and preclude the possibility of an automated non-compliance scenario. Some vendors allow their software to run on an unlicensed host within the same cluster for limited periods of time. Such usage must be tracked to ensure compliance and vSphere logs can be mined for this information.

See **Appendix A** for a complete example of configuring host affinity rules.

4.1.2.3 Anti Affinity Rules

Anti-affinity rules keep virtual machines apart from one another. For example, it does not make sense to run a standby database on the same physical host as the primary database. Likewise in a cluster scenario, virtual members should run on separate hosts. Anti-affinity rules can be used to facilitate this type of separation.

See **Appendix B** for a complete example of configuring anti-affinity rules.

4.1.3 VSAN

The question about VSAN having license implications often comes up because VSAN has the ability to pool storage from multiple locations into a virtual SAN volume, and licensed software could be present within a VMDK residing on such distributed storage.

VSAN, in and of itself does not have any direct licensing implications. Vendors license servers (or VM hosts), and NOT usually disks or disk volumes. There is no licensing obligation in the Oracle contract for SAN controllers, which themselves are powerful computers, just because a volume on that SAN contains their software. Even if the SAN controller is running a version of an embedded operating system, such as Windows or Linux, and could *theoretically* run the vendor's software, such a contractual term would not make sense because doing so would be impractical. VSAN software runs within the ESX kernel. To that extent, it could be considered to be a SAN controller of sorts. Although ESX/ESXi is running on x86 hardware, it is clearly not capable of running most vendors' software, including Oracle.

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The litmus test for "running" should be obvious – a CPU must be executing the vendor's code. However, some vendors take it a step further and assert a contractual licensing privilege by virtue of the fact that their software is installed. This is the case with the Oracle contract's "installed and/or running" language. Our suggested litmus test for "installed" is whether the code is visible to a platform in such a manner as to be executable on that platform. For Oracle, the Universal Installer (or opatch) could be run to reasonably demonstrate that Oracle was installed on that platform. So derived requirements to establish a state of installed, are 1) a booted operating system and 2) a mounted file system visible to that operating system.

We've repeatedly established that the presence of Oracle software in a VMDK, or any other SAN volume, does not qualify as being "installed and/or running" unless there is also a server or guest attached to that storage which could reasonably execute it. In that case, the server (or host where the VM resides) is what must be licensed.

A use case example is SAN replication of a software volume to a remote site for Oracle workloads. Unless there is a server attached to the SAN volume at the remote site that can make use of a vendor's software, such software is neither installed nor running on any platform at that site. Until that condition changes, there are no licensing requirements, and no reasonable assertion can be made to the contrary.

4.1.4 vSphere/ESXi CPU Affinity

CPU affinity has been available as a VMware feature since early versions of the hypervisor. It is used to assign a virtual machine to run only on specific processor cores. Using this feature, we can limit the processors available to a particular virtual machine and therefore *significantly* reduce the licensing requirements for many fee-based products, including Oracle. Using this as a licensing strategy can dramatically reduce licensing cost, but at the expense of increased administrative overhead as well as loss of vSphere functionality and performance as discussed below under implications.

It should be noted that Oracle states in their Partitioning Policy document that VMware cannot be used for "Soft Partitioning" (this is what Oracle refers to when a customer tries to limit the number of cores in a single server that need to be licensed). As we showed in Section 2.4.1, however, Oracle's Partitioning Policy document is not contractually binding. Because this practice is not contractually prohibited, we encourage our customers to consider its applicability in their own environments.

In addition to the contractual position, administrators must carefully weigh the performance implications and operational limitations against the potential license cost savings. The following sections describe the factors that must be considered.

Because of these operational limitations of using CPU affinity to limit the cores that need to be licensed, House of Brick recommends as a best practice either licensing all cores within a physical host and using consolidation strategies to leverage the host to its maximum potential, or using any of the following methods to limit the number of cores that need to be licensed in a given server:

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- Disabling of a socket through BIOS settings
- Leaving a socket vacant (no chip installed)
- Using specialty chips with limited core counts

4.1.4.1 Operational Considerations for CPU Affinity

CPU affinity does not guarantee cores; rather it denies all other cores to this VM. Currently there is no way for vSphere to guarantee particular cores to a VM. The Latency Sensitivity feature, which was introduced in vSphere version 5.5, allows virtual machines to exclusively own physical cores, thus avoiding overhead related to CPU scheduling and contention (See VMware document on Deploying Extremely Latency-Sensitive Applications for details).

Affinity can be used to assign logical processors to a VM. Most vendors are agnostic when it comes to logical processors and their licensing is based on processor cores regardless of thread count per core. For Intel hyper-threaded systems, a logical processor is a thread. So an eight-core host with hyper-threading has 16 logical processors (numbered 0 through 15) that could be assigned to a VM. Logical processors are assigned incrementally, so 0 and 1 are hyper-threads that belong to the first processor core. Without hyper-threading, the same host would only show 0 through 7 as available processor cores. You should avoid assigning core 0 (logical processors 0 and 1) to a VM using the affinity settings since the first core should be reserved for the hypervisor.

One potential application of CPU affinity is in creating a reduced-core environment for limiting the license footprint for expensive software products, especially if those products are not needed for every virtual machine. As an example, this might include Oracle Business Intelligence in either Enterprise Edition or Foundation Suite, or Oracle Essbase. This approach might be especially applicable in environments where your policy mandates uniformly configured vSphere host hardware.

4.1.4.2 CPU Affinity Implications

Manual specification of CPU affinity for VMs reduces the efficiency of scheduling the VM. It may also impact performance of the VM and has the following implications:

- It reduces the scheduler's ability to balance load across processors.
- It can interfere with the ESX/ESXi host's ability to meet the reservation and shares specified for a virtual machine.
- Because CPU admission control does not consider affinity, a virtual machine with manual affinity settings might not always receive its full reservation.
- Virtual machines that do not have manual affinity settings are not adversely affected by virtual machines with manual affinity settings.
- When you move a virtual machine from one host to another, affinity might no longer apply because the new host might have a different number of processors.
- The NUMA scheduler might not be able to manage a virtual machine that is already assigned to certain processors using affinity.
- Affinity can affect an ESX/ESXi host's ability to schedule virtual machines on multicore or hyper threaded processors to take full advantage of resources shared on such processors.
- Affinity may severely impact latency-sensitive applications as a result of the impact to scheduling performance.

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4.1.4.3 Operational Limitations of CPU Host Affinity with VMware

Assigning CPU affinity to a VM introduces some operational limitations for the VM. While vSphere HA remains fully functional, the following features are not available:

- Fully automated DRS must be disabled for a VM before you can assign CPU affinity. This can be done under Virtual Machine options or as a cluster-level default setting.
- The vMotion feature is disabled for VMs with CPU affinity.
- This implies that Fault Tolerance is also disabled.
- Care must be taken when creating new VMs to ensure that they only run on licensed processors.
- There is currently no log to demonstrate compliance as it relates to CPU affinity. However, configuration history should provide an acceptable alternative.

In our September 17, 2014 blog post, we mentioned this caveat:

> "Here is the single test we have run for this issue. We attempted to configure Core Affinity through the Virtual Center Server client on a two-CPU sever and assign the VM to non-existent core 3. The user interface rejected that as core 3 didn't exist. To further the test, we then edited the .vmx file to assign the VM to core 3. The purpose was to simulate a VM that had been assigned to a disabled or non-existent core, or to simulate vMotion to a server that did not have the same core available as the source server. When we started the VM, it started without regard to the core affinity assignment. The log file shows the VM came up on CPU 0 with no warnings or messages."

If CPU Affinity-assigned cores are unavailable for whatever reason (CPU chip removed from a socket, BIOS-disabling of a socket on one or more cores, or a core defect), it is our experience that CPU Affinity currently employs a "best effort" only to respect that affinity rule on VM boot. What this means is that ESXi may start the VM on available cores outside of the CPU Affinity assignment. For licensing risk management reasons, House of Brick is looking for warnings similar to what Linux provides for Huge Pages. Huge Pages has a parameter option that prohibits the start of the OS if the configured Huge Pages memory is unavailable. For core assignment integrity, ESXi should provide a VM boot warning that the CPU Affinity-assigned cores are unavailable and ask for permission to continue the VM boot onto other available cores. Such a warning could be similar to the dialog box that asks whether the VM has been moved or copied. Without such protections, House of Brick cannot endorse CPU Affinity as a best practice for our customers.

4.2 Storage Replication

4.2.1 SAN Tooling (SRDF/Recover Point)

When SAN volumes are replicated, the replica is not typically available at the remote site until further action is taken to present it to a physical host. As such, replicated volumes cannot be considered to contain "installed" software for any current RDBMS vendors. See section 4.1.3 VSAN for further details.

Further, when used to replicate any form of customer data, including Oracle data files and/or archived redo, this type of replication does not constitute any licensable activity.

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4.2.2 vSphere Replication Service (vRS)

vRS is a form of replication. It replicates VMDK files associated with a VM from one vSphere datastore to another. While being replicated, VMDKs are not available to be used by VMs at the secondary location. For that reason, even if they contain licensed binaries, replicated disks cannot be considered to contain "installed" software for any current RDBMS vendors. See section 4.1.3 VSAN for further details.

Further, when used to replicate any form of customer data, including Oracle data files and/or archived redo, this type of replication does not constitute any licensable activity as the Oracle license is software-based, not data-based.

4.2.3 Oracle Data Guard

Oracle Data Guard is a form of replication specific to Oracle software. It is used to maintain a standby copy of an active database. It requires Oracle software to be running at both the primary and standby locations. Therefore, this form of replication clearly requires licensing of both the primary and the standby locations.

4.2.4 Standby Database

Oracle Data Guard is a set of tools built around the standby database concept. Other vendors have similar concepts and capabilities. One method of maintaining a standby includes the use of vendor-provided transport mechanisms to send archived redo logs to one or more alternate locations. Any such transport mechanism that executes vendor software must be licensed accordingly.

However, it is possible to copy data files and archived redo logs to alternate locations using commonly available mechanisms outside any RDBMS vendor's capability. This type of replication, including SAN Tooling and vRS, does not constitute a licensing requirement. Obviously, to make use of these artifacts would require vendor software and any attempt to do so, would require a platform to be licensed accordingly. But simply transporting and storing the artifacts does not.

4.3 Disaster Recovery (DR)

When workloads are virtualized there are several different possibilities for establishing a Disaster Recovery strategy. Tools at the infrastructure, vSphere and database layers can be utilized and have different pros, cons, and costs.

For Microsoft SQL Server, if you have purchased Software Assurance, you have the ability to migrate your licenses at will from one host to another host. This is a tremendous advantage in being able to instantly move licenses to the DR site when a disaster is declared and those virtual machines are started.

For Oracle, it is a bit more complex. The Oracle contract allows for the following that are beneficial for possible DR strategies, but the application of these features will depend on the version of the OLSA that you are using, as discussed in the following section.

- Backup testing - allows a customer to test the restoration of backups to an unlicensed server four times a year for two days each time.
- 10-Day Rule - allows a customer to failover to, and then back from, an unlicensed node for a total of 10 days per year.

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4.3.1 Oracle OLSA Versions Prior to Q4-2007 Template

If you have an OLSA that is dated prior to the Q4-2007 template, you have certain advantages for DR that are not available to customers with later agreements. In the later versions, Oracle tightened the so-called 10-Day Rule in its contract template. The unlicensed server privilege is now only valid if production and the unlicensed failover hosts are not active concurrently, if the failover host shares a cluster and storage system with the protected node, and if only one failover host is used per cluster regardless of the number of products protected. You can no longer locate your 10-Day Rule host in a remote data center.

4.3.2 vSphere Site Recovery Manager (SRM)

When a VM image is replicated to a remote site, and the VM is not in the vCenter inventory at the remote site, then the image can be considered a backup (it is nether installed nor running). It is allowable to keep backups at remote facilities. With this in mind, one possible DR strategy is to use VMware Site Recovery Manager and storage replication (as discussed below) to utilize an unlicensed server for DR within the licensing terms. For Oracle, this allows for the use of the backup test rule so that DR can be tested up to four times per year and a maximum of two days for each test. It should be noted that this provision of testing a backup virtual machine is only allowable in Oracle contracts roughly before 2013 (we are not sure exactly when this changed, but about this time). Starting in 2013, Oracle modified the backup test provision so that you could not use it if your data recovery method copied or synchronized any Oracle program binary files. This means that a DR method of backing up entire virtual machines would not qualify for the test provision. You should verify your own agreements to see what applies in your situation.

The first pre-requisite for using SRM is some form of replication that copies a virtual machine and, optionally its data, to another location. See section 4.1.3 VSAN for a discussion of the corresponding license implications.

SRM works to coordinate the state of a protected VM between primary and secondary sites. Under normal circumstances, the VM is only actually booted at the primary site. And all that exists at the secondary site is the definition of the VM, called a placeholder. The placeholder consists of a synchronized copy of the VM configuration file(s). It cannot be booted, and is not assigned to any physical server. Neither is it attached to any VMDKs or other storage currently available at the remote site. In order to determine whether the placeholder must be licensed, we need to refer to our license agreement with any applicable vendors. If required, we would most likely have to license the placeholder using the same method as the primary.

Taking Oracle as an example, we have to determine if Oracle software is either installed or running on the placeholder VM. Clearly it is not running, since the placeholder cannot be booted. So, does our litmus test confirm that it is installed? Again, the answer has to be "no", since there is no booted operating system and no mounted file system. To test whether it's installed, we would have to reconfigure the placeholder to instantiate a VM, which involves the following steps:

1. Suspend replication to the datastore on which the VMDK exists, and/or create a consistent snapshot of the replicated volume.
2. Mount the datastore to vSphere host(s).
3. Modify the local configuration for the VM to be able to run.

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   a. This includes associating the VM with a copy of the VMDK that contains Oracle software.

   b. At this point the *definition* of a VM finally exists in what could be considered a usable form. But, the VM is not yet associated with any host, so until the VM is booted on a physical server, we can't quantify where any software in question might be installed. Nor can we run any kind of tool to test whether it's installed.

4. Assign the VM to a physical host, and boot the guest operating system.

   a. At this point all reasonable observation would have to conclude that it's finally possible to determine if the Oracle software is installed on the VM or not.

   b. Also, the VM is now running on a host, which gives us a quantifiable metric for license consideration. Once we can login to the guest O/S, we will be able to run tools to demonstrate that the Oracle software is (or is not) installed.

5. Optionally, the Oracle software can be started either manually or automatically during boot. This is moot since it would obviously require the test for "installed" to already have been met.

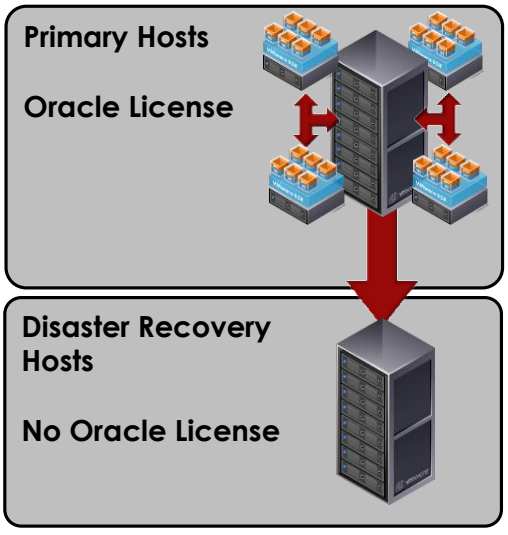
Once the preceding steps have been accomplished, the answer to the question of requiring it to licensed clearly changes to "yes". The host on which it is now both installed and running must be compliant with the Oracle license terms.

4.3.3 Sample DR Architecture

For Disaster Recovery (DR) we recommend an architecture solution similar to the following (and as previously described in Section 2.4.9.2):

1. As illustrated, all of your virtual machines should stay on the licensed primary servers.
2. Do not run the virtual machines (i.e. do not start them or even include them in the vCenter inventory) at the disaster recovery site. This means that they are neither "installed" nor are they "running." Note: Using SRM does not cause the VM at the remote site to be defined, it just provides a placeholder as previously discussed.
3. Use replication between the storage arrays at the primary and secondary data centers to replicate all data (including virtual machine files).

Figure 12: DR Configuration to Limit License Costs



4. Use VMware Site Recovery Manager to perform periodic DR tests. Tests can be done by running the virtual machine on a licensed host, or you can use the backup test and/or 10-day rule provisions in your OLSA (if they are available and applicable to the environment) to run those virtual machines on the unlicensed DR host as discussed above.
5. The backup and10-day rules should be used scrupulously as well as tracked and documented.

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5 Appendix A: Host Affinity Rules

Host affinity rules restrict certain virtual machines to specific hosts for automated vSphere operations, primarily DRS. This can be considered to be "positive host specification", whereby a VM can only run on designated hosts. This is especially useful to assist clients with managing host-based license compliance.

NOTE 1: These rules can easily be violated without warning by manual operations such as vMotion and host selection at power-on. For that reason, when used as part of a licensing strategy, additional procedures are advisable to alert vSphere administrators and prevent inadvertent violations through otherwise routine operations.

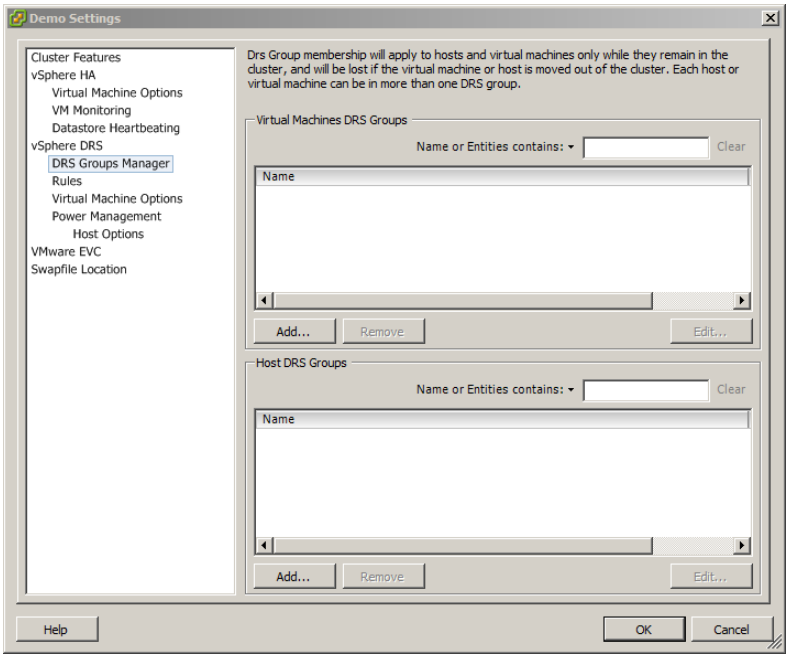
NOTE 2: By default, vSphere HA does not honor these rules during a failover event. If these rules are part of a licensing strategy, or it is otherwise desirable for them to be honored by vSphere HA, then refer to KB 2033250 for advanced settings that can change the default behavior in vSphere 5.5 and above. Specifically, we need to change an advanced setting called das.respectVmVmAntiAffinityRules to "True". This could cause a VM not to power on during a failover event if a host that satisfies the DRS rule cannot be found.

We can deliberately circumvent these rules to invoke the Oracle 10-day rule and run on an unlicensed host within our licensing terms.

To set up host affinity rules, you first need to set up host groups and VM groups.

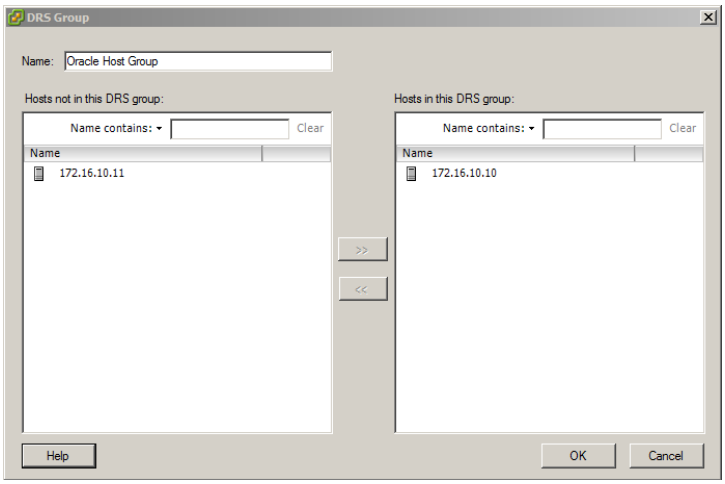
Step one, as shown in Figure A.1, is to configure a host group. To do this, right click on the cluster and click Edit Settings. Click DRS Groups Manager and click the Add button under Host DRS Groups.

Figure A.1 DRS Group Manager



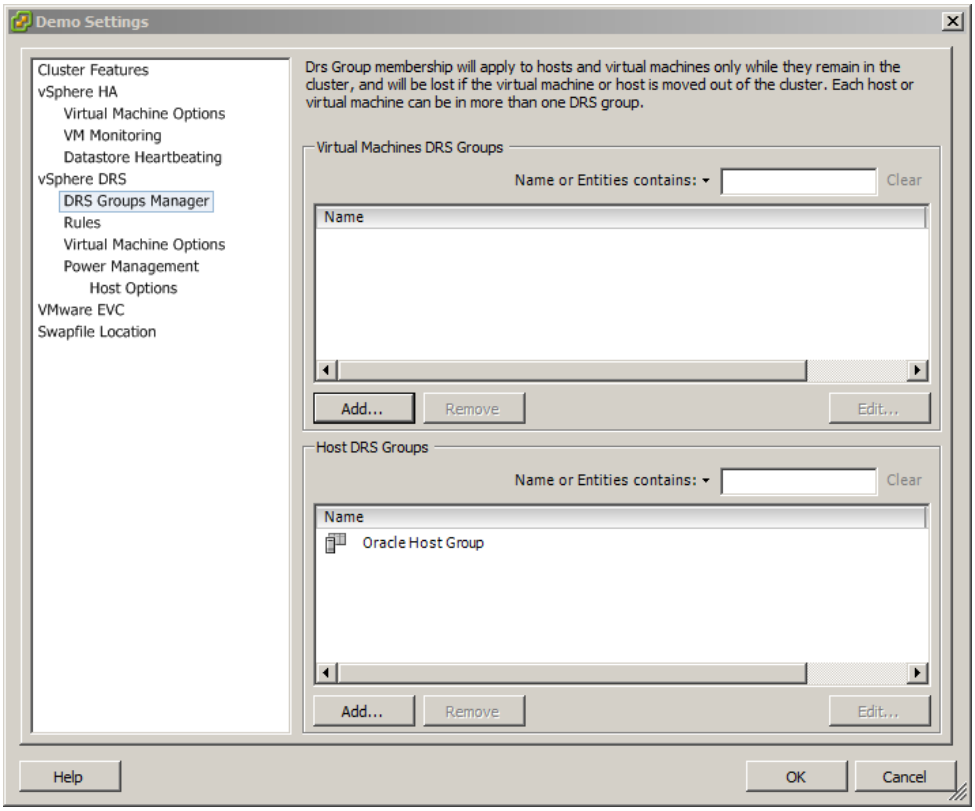
In Figures A.2 and A.3, we will show how to designate one host to be the database host.

Figure A.2 Database Host Designation



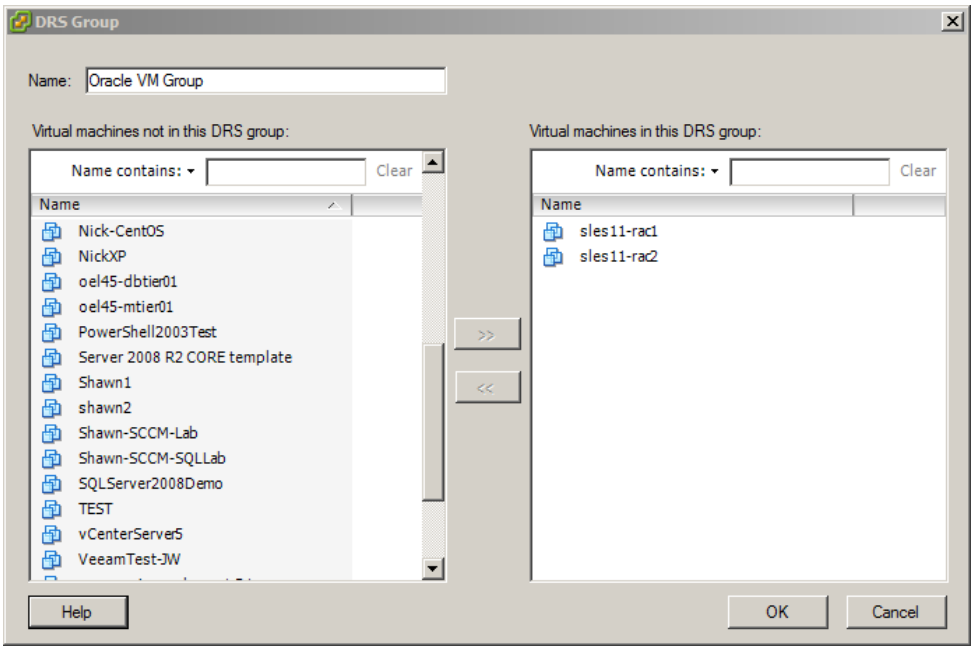
Click OK to add the group.

Figure A.3 Add Host Group



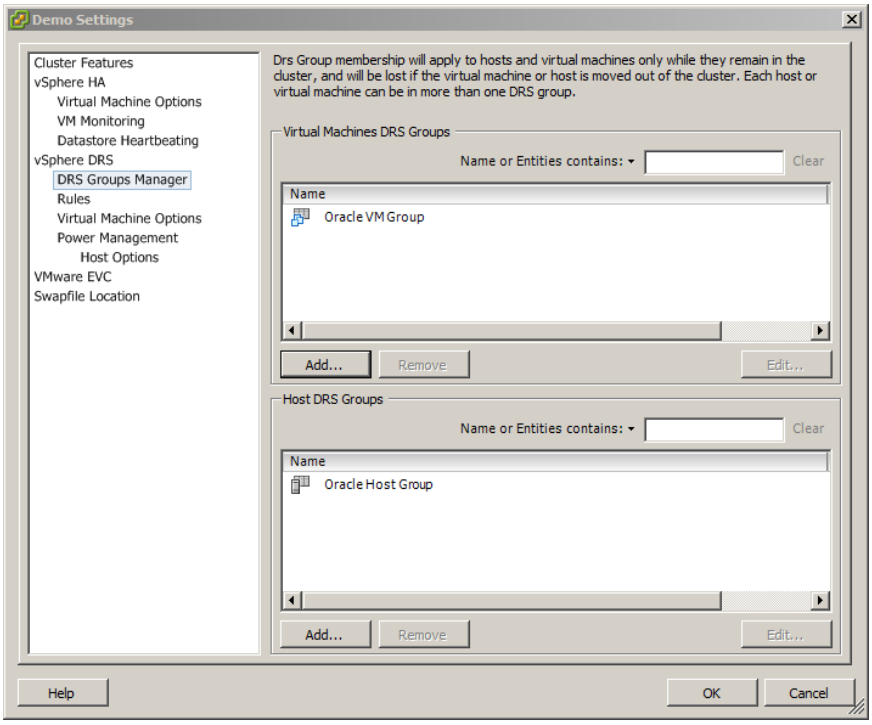
Next, add a VM DRS group by clicking Add under Virtual Machines DRS Groups. Choose the virtual machines to add to the group and click OK to add the group, see Figure A.4.

Figure A.4 Add VM DRS



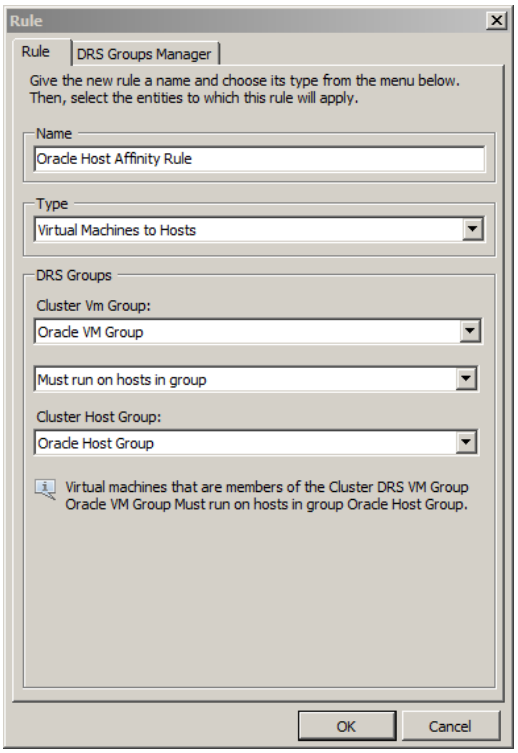
Next, click on Rules. Click the Add button to add a rule, as shown in A.5.

Figure A.5 Add a Rule



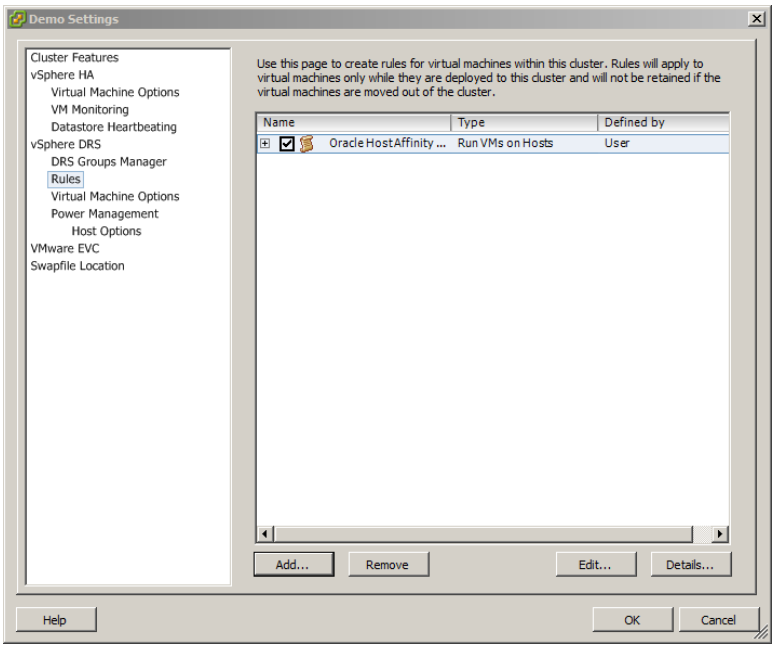
Click on Rules to add the host affinity rule, see Figure A.6.

Figure A.6 Add Host Affinity Rule



Click OK to add the rule, as shown in Figure A.7.

Figure A.7 Add the Rule



Click OK to save changes.

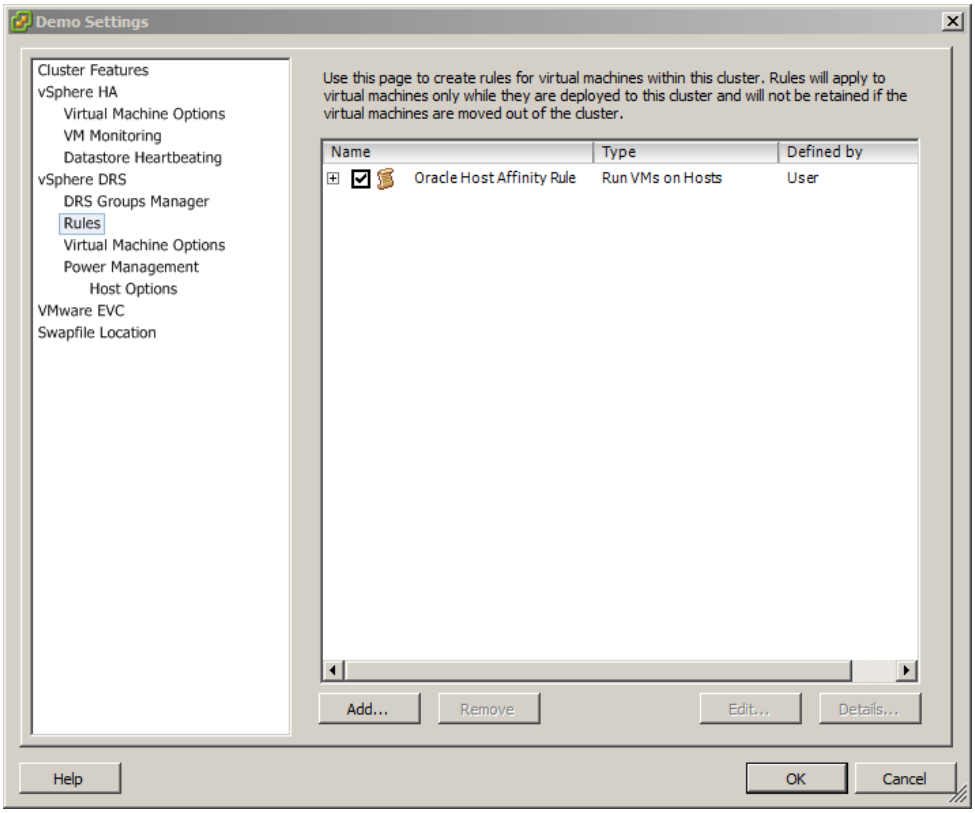
6 Appendix B: Anti-Affinity Rules

These rules are used in the same manner and with the same precautions as noted under affinity rules. We do not recommend using host anti-affinity rules (or negative host specification) for licensing purposes; because it is less restrictive than positive host specification described in Appendix A and will not prevent VMs from running on new hosts added to the cluster.

VM anti-affinity rules are designed to enforce rules when it makes sense to force virtual machines to run on different hosts. This can be especially useful for high availability considerations when the primary VM should run on a different host than the secondary VM to eliminate downtimes from hardware failures.

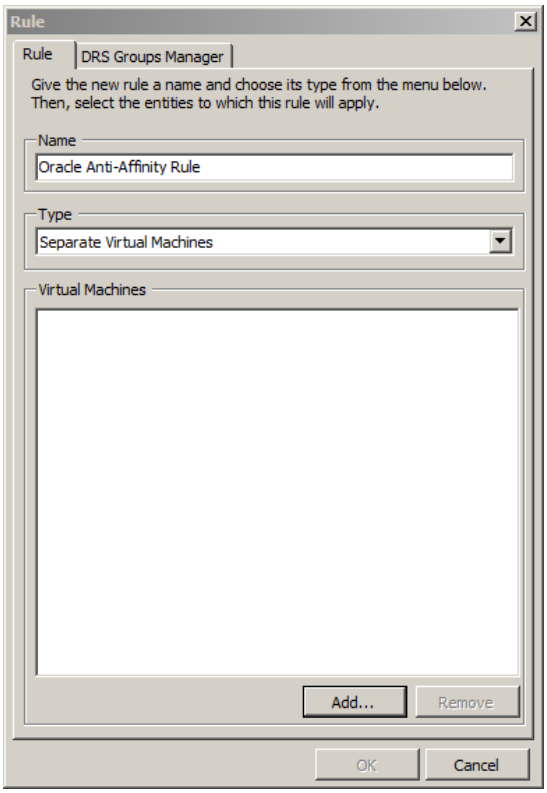
To set up a VM anti-affinity rule, right click on the cluster and click Edit Settings, see Figures B.1 through B.5.

Figure B.1 VM Anti-affinity Set-up



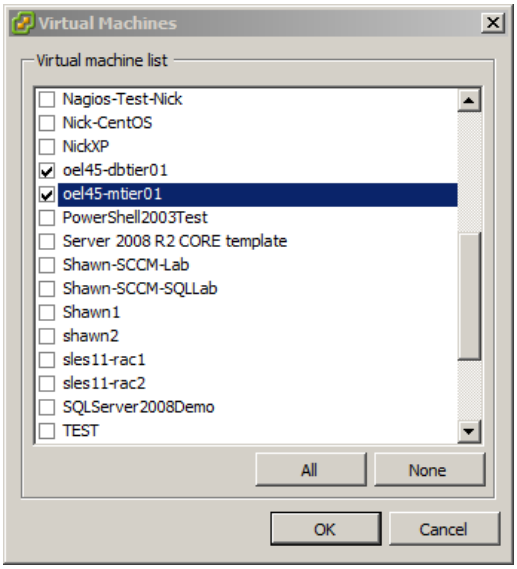
Under vSphere DRS click on Rules and click Add to add a rule, see figure B.2.

Figure B.2 Add a Rule on vSphere DRS



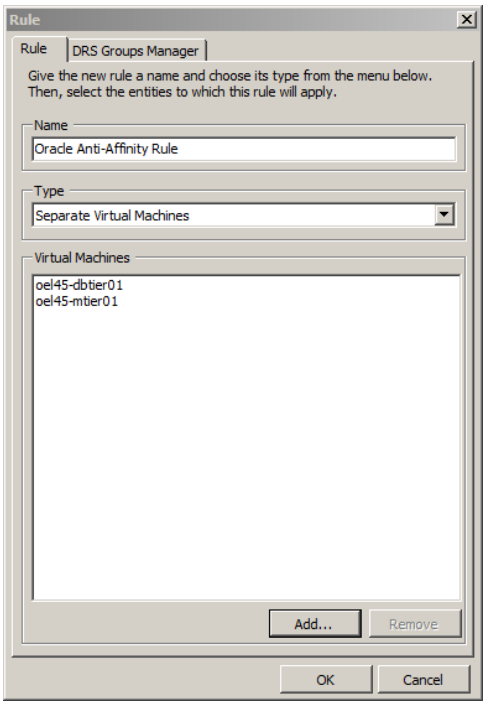
Choose Separate Virtual Machine and click Add to add the virtual machines to the rule.

Figure B.3 Add VM to the Rule



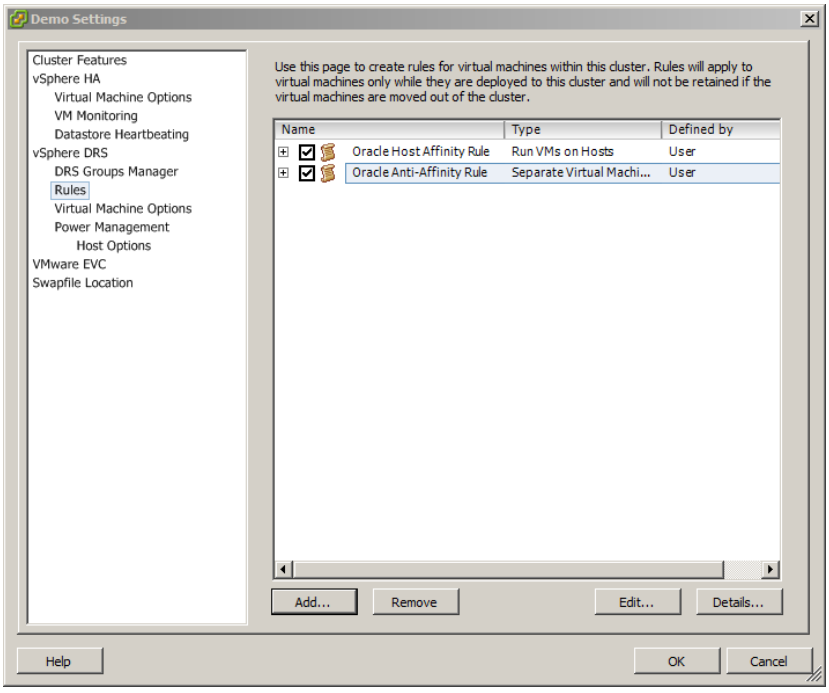
Click OK to add.

Figure B.4 Click Add



Click OK to add the rule.

Figure B.5 Save Rule Change



Click OK to save the changes.