

Oracle Application Server 10g - Grid Computing

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INTRODUCTION

Every organization around the world struggles with the very high cost of its information technology infrastructure. These very high costs arise from three primary factors:

- **Excess Computing Capacity:** that is poorly utilized due to the need to build capacity for peaks, and the inability to use the spare capacity efficiently.
- **Expensive Capacity Growth:** due to the inability to add capacity quickly, when needed, and in low cost, modular units.
- **High Management Costs:** due to the complexity of systems; the specialized management tools, procedures, and skills required; and the large amounts of human intervention needed to manage systems.

Grid computing is a new software architecture designed to effectively pool together large amounts of low cost modular storage and servers to create a virtual computing resource across which work can be transparently distributed. Grid computing enables computing capacity to be used very efficiently, at low cost, and with very high availability. The *resources* in a grid can include storage, servers, database servers, application servers, and applications. By pooling resources together, grid computing can offer dependable, consistent, pervasive, and inexpensive access to these resources regardless of their location and when needed. Grid computing thereby provides the best solution to the need for computing and *software capacity on-demand*.

While grid computing has hitherto been primarily used by the scientific community to solve very specialized problems, the rapid evolution of cost-effective networked storage; high speed, high density blade servers; high speed network Interconnects; and low cost operating systems coupled with the advances in systems software (Database Servers and Application Servers) to exploit these advances have now made it possible for enterprises to exploit grid computing. *Enterprise grid computing* has been made possible by four major innovations:

- **Standardization** on low-cost, high-density modular servers and storage based on technology such as Tannin processors, blade servers and Linux.
- **Consolidation and Virtualization** of storage and servers shared across one or more data centers.
- **Automation** of all day-to-day management tasks, enabling a single administrator to simultaneously handle hundreds of servers in clusters.

- **Abstraction** of infrastructure services such as identity management for applications through application services layer using distributed computing technologies like Web services.

Recognizing the fundamental benefits grid computing offers enterprises, Oracle offers organizations a comprehensive solution to manage information and run enterprise applications on grids. Oracle Database 10g has been designed to manage information on computing grids called *database grids*. Oracle Application Server 10g (OracleAS 10g), component of Oracle Fusion Middleware, has been designed to run enterprise applications on computing grids called *application server grids*. Both Oracle Database 10g and Oracle Application Server 10g can be very efficiently managed in a grid computing environment using Oracle Enterprise Manager 10g Grid Control. Together these products address the information technology challenges that organizations face:

- **Eliminating Excess Computing Capacity:** Through automatic workload management that distributes workloads to use spare computing capacity efficiently.
- **Enabling Modular, Inexpensive Capacity Growth:** Through rapid and efficient software provisioning that enables computing capacity to be added on-demand in low cost modular units.
- **Radically Lowering Management Cost:** Through self-managing systems that reduce the need for costly, error-prone human intervention; and through automated software provisioning and management across many systems.

ORACLE APPLICATION SERVER 10g GRID COMPUTING FEATURES

Oracle Application Server 10g

Oracle Application Server 10g, component of Oracle Fusion Middleware, has been specifically designed to run enterprise applications on computing grids. It is designed to run enterprise applications on pools of low cost servers and storage with very high performance, scalability, and availability while radically reducing the costs of systems and applications monitoring and management. Further, customers can deploy all their existing Oracle9iAS applications on Application Server 10g without any changes and take advantage of the new grid features.

OracleAS 10g is managed by Oracle Enterprise Manager 10g Grid Control, a web-based management console that enables administrators to manage many application servers as though they were one, thereby automating administrative tasks and reducing administrative costs. Grid Control also provides facilities to enable many administrators to work together to manage an application server grid. Finally, OracleAS 10g is also integrated with Oracle Database 10g in many different ways to optimize quality of service across a unified grid computing infrastructure for data management and enterprise applications.

Before we examine the specific features OracleAS 10g provides for grid computing, it is important to first understand the characteristics of grid computing that drive the need for these features.

Grid Computing Characteristics:

An enterprise computing grid is characterized by three primary features - Diversity; Decentralization; and Dynamism.

Diversity: A typical computing grid consists of many hundreds of managed resources of various kinds including servers, storage, Database Servers, Application Servers, Enterprise Applications, and system services like Directory Services, Security and Identity Management Services, and others. Managing these resources and their life cycle is a complex challenge.

Decentralization: Traditional distributed systems have typically been managed from a central administration point. A computing grid further compounds these challenges since the resources can be even more decentralized and may be geographically distributed across many different data centers within an enterprise.

Dynamism: Components of a traditional application typically run in a static environment without the need to address rapidly changing demands. In a computing grid, however, the systems and applications need to be able to flexibly adapt to changing demand. For instance, with the late binding nature and cross-platform properties of web services, an application deployed on the grid may consist of a constantly changing set of components. At different points in time, these components can be hosted on different nodes in the network. Managing an application in such a dynamic environment can be a challenging undertaking.

These are just three of the most important challenges associated with running enterprise applications in a grid computing environment. Recognizing these challenges, Oracle designed its software infrastructure to run enterprise applications, OracleAS 10g, to specifically address these and other challenges.

Oracle Application Server 10g: Grid Computing Features

In the remainder of this paper, we will specifically examine the grid computing features of Oracle Application Server 10g. Note that Application Server 10g has many other new features that are not specifically related to grid computing and that are not discussed in this white paper. To organize the way in which we will discuss these features, we have divided the document into 5 sections, each of which discusses the features related to a specific aspect of using Application Server 10g for grid computing.

Software Provisioning: Oracle Application Server 10g automates the process of installing, configuring and provisioning software reducing labor costs and speeding-up the process of delivering software capacity on-demand.

User Provisioning: Once the software infrastructure has been provisioned, Oracle provides facilities to quickly and efficiently provision users and their identities and access control privileges across multiple resources and applications in a grid.

Application Management and Monitoring: As users access enterprise applications in a grid, OracleAS 10g has integrated facilities to monitor and tune applications to provide optimal performance to end-users.

Work Load Management: As performance and workload requirements change, OracleAS 10g's integrated and automated workload management features use

existing software capacity efficiently to provide optimal scalability and high availability while limiting idle computing capacity.

Systems Management and Monitoring: Finally, OracleAS 10g and Oracle Grid Control work together to provide comprehensive systems management and monitoring facilities in a grid computing environment.

Specifically, OracleAS 10g supports the following grid computing features:

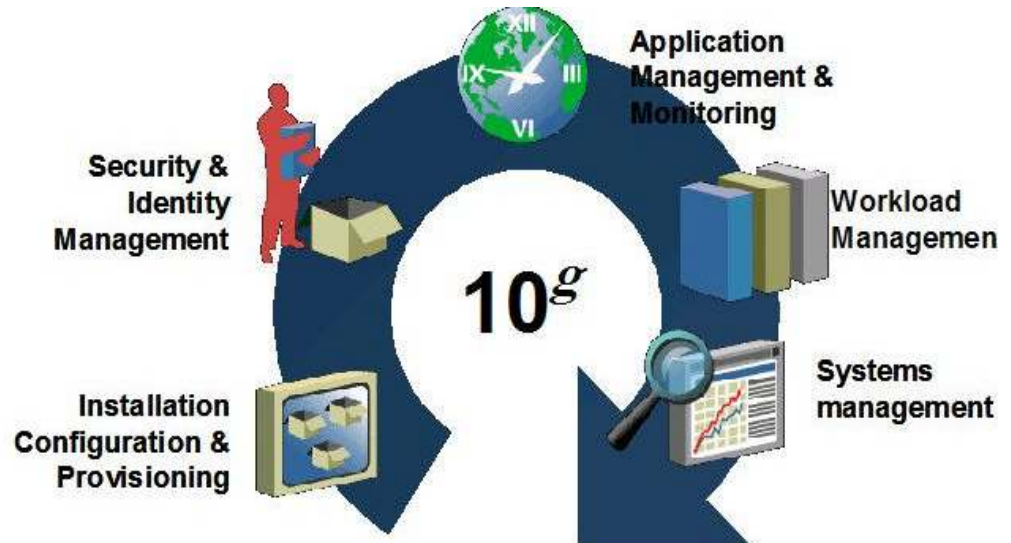


Figure: Oracle Application Server 10g – Grid Computing Features

SOFTWARE PROVISIONING

A typical grid computing environment can start with just a few servers and grow to hundreds of servers as resources are pooled together. Manually installing and maintaining software on hundreds of servers can be time consuming, cumbersome, and extremely error-prone. Application Server 10g provides a number of capabilities to automate and speed-up software provisioning. **Installation:** To streamline software installation, Oracle provides 100% automated *silent installation* procedures that enable all components of the Application Server to be installed on many machines without human intervention. Installation can be on a single server or many servers (*multi-node*), and has fully automated *pre and post-install checks* to ensure that the software installs correctly each time. **Configuration Management:** To streamline software configuration, Oracle Application Server has the ability to *automatically archive* multiple versions of its own configuration. These can then be automatically applied across a group of systems. Human configuration errors can be eliminated by automatically restoring systems to a *configuration baseline*. Systems administrators can spend up to 25% of their time installing and configuring new software.

The Configuration Management facilities can reduce the time spent to deploying new software by up to 80%.

Cloning: Oracle provides facilities to *clone* Application Servers, their configurations, and the Applications deployed on them. Cloning makes it more efficient to provision software capacity on-demand.

Patching: Oracle provides facilities to automatically apply software patches to one or more Oracle Application Servers, on one or more servers. The system can check the Metalink patch website to detect whether it has been patched appropriately to remedy any known bugs or potential security vulnerabilities. When violations are detected patches can automatically be downloaded, staged and applied to all affected systems.

Upgrade: OracleAS provides a graphical *Upgrade Assistant* to automatically upgrade Application Servers from 9iAS to 10g without human intervention and in 2-3 hours. It automatically detects what components of the Application Server need to be upgraded and upgrades them including installing new software, applying the appropriate configuration baseline from the old version to the new version, and deploying applications to the upgraded instances.

Operational Task Automation: Finally, Oracle Application Server and Oracle Enterprise Manager provide a number of services including an integrated Job Scheduler and Cluster and Group Management Services to automate day-to-day administration tasks across many Application Servers.

The figure below summarizes the key features in Oracle Application Server 10g and Oracle Enterprise Manager 10g to streamline software provisioning in a grid.



Figure: Oracle Application Server 10g – Software Provisioning

Oracle Application Server and Oracle Enterprise Manager together enable organizations to automate software provisioning, change management, patch application and management, and application deployment. Together these features reduce labor cost, reduce human errors, and speed-up delivery of software on-demand.

SECURITY, IDENTITY MANAGEMENT, AND USER PROVISIONING

A fundamental requirement to establish an enterprise computing grid is a well-defined and well-implemented security policy and procedure. Grid computing makes enforcing uniform security procedures more complex in two ways:

- **Dynamic Resources:** Since resources in a computing grid are no longer statically tied to applications but allocated on-demand, identity and access management procedures need to be applied on-demand.
- **Complexity of Resources:** Additionally, in a computing grid, the volume of users, the volume of resources they access, and the number of different devices and channels they use to access these resources all grow rapidly. Users need to remember many different passwords to access different resources; administrators need to enforce security in many different systems.

These factors can make security enforcement in a computing grid challenging and extremely expensive. To simplify security provisioning and management in a computing grid, OracleAS 10g provides a single, unified, standards based end-to-end Security and Identity Management infrastructure based on Oracle Internet Directory, OracleAS 10g Single Sign-On Server and OracleAS Certificate Authority.

Secure Application Server: To provide a secure environment to run Enterprise Applications, OracleAS 10g provides a number of security enhancements including comprehensive Java2 security support; SSL support for all protocols (RMI, RMI-over-IIOP, SOAP, JMS, LDAP..); a least privilege model for administrative privilege; and a comprehensive PKI-based security infrastructure.

User Provisioning & Administration: To provision users – create and revoke users, their identities and access control privileges, OracleAS 10g provides a Security Management Console to create users, roles, and to define user identity and access control privileges; a Certificate Authority to issue them certificates; a Delegate Administration Service that allows administration of user identities, roles and preferences to be delegated to various administrators or to users for self-service; and the ability to create dynamic groups of users.

Directory Services - Security Repository: To store definitions of users and roles, and their associated identities and access control privileges, OracleAS 10g provides Oracle Internet Directory, a standards-based LDAPv3 compliant Directory Service. Oracle Internet Directory uses a database-backed repository for user information with highly optimized algorithms to store large user populations and to support a variety of fan-out replication models to synchronize this information with other directories. It also supports external authentication models to allow it to co-exist with non-Oracle authentication services.

Integrate with Other Security Environments: To enable Oracle Application Server to co-exist in a multi-vendor computing grid, Oracle provides a number of mechanisms to integrate with heterogeneous security environments including Windows Native Authentication services; Active Directory, iPlanet, OpenLDAP and other Directory Servers; and legacy security environments. Oracle offers Directory Integration Service, a feature of Oracle Internet Directory that enables use of other enterprise user repositories. Oracle also offers Directory Provisioning

Integration Service to automate user provisioning across Oracle's Directory and Packaged Applications including out-of-box support for e-Business Suite.

Single Sign On (SSO) in a Grid: Finally, to enable users to authenticate to a number of Applications or Services in a grid, Oracle provides an Enterprise Single Sign-On Service. There are two ways that developers can leverage the Single Sign-on facility. First, a developer can build an application that defers the user password checks (authentication) to the SSO Server in a grid. These applications are called "*Partner Applications*" since they assume a trusted relationship with the SSO Server. The second type of application, an "*External Application*," retains its own security model. When "Partner Applications" are configured for single sign-on in a Portal, users only need to log into the Portal itself to be automatically authenticated with these other applications. With External Applications in a Portal, users do not need to separately login to the external applications. The first time the user clicks on the Portal link to the "External Application," they are prompted for their username and password. The next time the user logs in to the Portal, their passwords will have been remembered for them. The SSO Server manages the application passwords in a "password vault" that adheres to the highest security standards.

The figure below summarizes the key features in OracleAS 10g to streamline user provisioning, and identity and access management in a grid.



Figure: Oracle Application Server 10g – Security & Identity Management

OracleAS 10g's Security and Identity Management Services to automate the process of provisioning users; the creation and deletion of their identities; and

their access control privileges. These facilities reduce labor costs for security administration; reduce security loopholes; and speed-up giving users access to the applications and grid resources to which they are authorized.

APPLICATION MANAGEMENT AND MONITORING

Computing grids have a large pool of shared systems infrastructure supporting large numbers of enterprise applications and users. Quality of service issues such as poor performance and outages in this environment simultaneously affect large numbers of users. Centrally and pro-actively monitoring and managing applications is therefore critical in a computing grid. OracleAS 10g provides a number of capabilities to improve and automate Application Monitoring and Management in computing grids. It also automates the complete life-cycle management of applications running on grids.

Configuration & Deployment: With OracleAS 10g, J2EE Applications, Web Services, Portals, Forms & Reports, and Business Intelligence Applications can all be configured and “hot-deployed” across one or more servers in a grid from Oracle Enterprise Manager.

Performance Tuning and Debugging: OracleAS 10g’s Dynamic Monitoring Service (DMS) collects resource consumption metrics such as CPU, Memory, and I/O and performance metrics such as Response Time, Requests/Second, and Transaction Throughput. DMS allows you to monitor both the duration of important phases of request processing as well as status information such as the number of requests being handled at any given moment. DMS provides this instrumentation out-of-the-box and without any changes to the application.

Application Performance Monitoring: OracleAS 10g and Oracle Enterprise Manager’s Application Performance Monitoring (APM) enable administrators to monitor the real performance of an application to an end-user (“click-to-render” performance) and the time spend for a specific transaction in various infrastructure components - the network, Web Servers, Application Servers, and Database Servers. For the first time, Administrators have the ability to monitor their e-business systems from the top down and trace the experience of their real end-users as they enter and navigate a grid enabled Application. Root-cause analysis enables rapid and accurate problem diagnosis and resolution. In-depth reports provide administrators with a complete view of the performance of their applications.

Integrated Systems and Application Monitoring: Finally, Oracle Enterprise Manager 10g Grid Control enables administrators to relate the monitoring and management of their applications to the systems infrastructure on which these applications run. They can define availability metrics for specific applications and tie them to the monitoring of discrete infrastructure components to get a comprehensive view of an application’s performance and availability to end-users. Further, Grid Control allows contextual drill-downs from Web Application performance metrics into the underlying infrastructure, enabling root-cause analysis of performance bottlenecks.

As a result, with Application Server and Oracle Grid Control, administrators have a comprehensive and integrated view of their systems and applications in a single

place vastly improving how quickly and accurately administrators can diagnose problems with their Applications. This reduces labor costs and errors, and improves Application Performance and Availability

WORKLOAD MANAGEMENT – SCALABILITY AND HIGH AVAILABILITY

As performance and workload requirements change, OracleAS 10g's integrated and automated Workload Management features use existing software capacity efficiently to provide optimal scalability and high availability while limiting idle computing capacity. Specifically, OracleAS 10g is designed to provide On-demand Scalability and end-to-end High Availability and Failover across hardware failures, software failures, human errors, and disasters.

Scalability and Resource Management

OracleAS 10g provides a number of facilities to ensure that Systems and Applications can use available system resources efficiently to provide maximum scalability on low cost servers and storage. These facilities include:

Application Server Optimizations: OracleAS 10g has a number of resource pooling, connection management, transaction management, network I/O, and scheduling optimizations to scale-up applications on single CPUs or blades.

Workload Monitoring: OracleAS 10g is pre-instrumented with a Dynamic Monitoring Service (DMS) that monitors resource (CPU and Memory) usage by Multiple OracleAS 10g instances; Components within a single OracleAS 10g instance; multiple OracleAS 10g Applications. These can be tied to policy baselines that can be monitored from Oracle Grid Control enabling alerts to be raised if performance falls below specific thresholds.

Policy-Based Workload Management: OracleAS 10g provides a sophisticated Workload Manager that enables automated and administrator-set policies for workload management. Multiple load-balancing algorithms can be used to direct workloads to specific servers, Application Server instances, and Applications efficiently. OracleAS 10g can automatically track these algorithms and generate recommendations to administrators on what policy would be optimal for the workloads on the system.

Application-Specific Policies: OracleAS 10g also has the ability to support different workload management policies for specific applications based on the characteristics of the Application itself. For instance, a workload management policy that is optimal for a Web Application may be less than optimal for a high performance transaction processing application. As a result, OracleAS 10g provides administrators with greater flexibility in optimizing workload management policies based on the kind of workloads being run.

Service Provisioning and Dynamic Resource Allocation: Finally, Oracle AS10g also provides the ability to dynamically reconfigure system resources and Applications, enabling and disabling specific components and starting and stopping components dynamically as resource requirements shift. These resources can be on one server or on many servers (multi-node) and the Application Server automatically tracks and maintains dependencies across this environment. For

instance, before starting a new instance of an Enterprise Portal as the volume of Portal users grow, it can ensure that the associated Single Sign-On and Directory Services are already configured and started.

The figure below captures the Scalability and Workload Management features in OracleAS 10g.



Figure: Oracle Application Server 10g – Scalability & Workload Management

The Workload Management features of OracleAS 10g are designed to provide maximum Scalability using efficient computing capacity as efficiently as possible and the ability to add capacity quickly and efficiently as loads on specific systems or Applications grow. These features ensure that Applications run with excellent Quality of Service while using computing resources and capacity efficiently.

High Availability

OracleAS 10g provides a number of facilities to ensure that Systems and Applications run with maximum availability on low cost servers and storage. These facilities include:

Zero Planned Downtime: Facilities to eliminate downtime that arises from carrying out planned maintenance operations on the Application Server. These include: (i) *Rolling Upgrade* to upgrade Oracle9iAS to OracleAS 10g without downtime; (ii) *Configuration Archive and Flashback* to address human configuration errors by automatically rolling back configuration to a specific point in time.

Zero Unplanned Downtime: Facilities to eliminate downtime that arises from system failures, human errors, or disasters. These include (i) *Integrated Process and*

Fault Monitoring including dependency analysis to provide automated failure detection and recovery either in a single server or multi-server environment; (ii) *Cold Failover and Active Failover Cluster* solutions to provide automatic failover in the event of hardware or software failures. OracleAS 10g automatically detects component failures and restarts failed components. While components have failed, Application Session State is automatically migrated to live instances and the incoming traffic is re-directed to these instances transparently without end-users ever knowing the failover. (iii) *Automated Backup and Recovery* to provide automated, incremental backups and point-in-time recovery of Application Servers including software, configuration, and applications; (iv) *Disaster Recovery* to provide the automated creation of Standby Application Servers along with Standby Databases to protect systems against disasters.

Failover Notification (FaN): To improve end-to-end High Availability, Oracle has integrated the Fault Monitoring and Notification Services of the Application Server with Oracle Real Application Clusters (RAC). When a RAC node fails, Oracle Application Server receives a Failure Notification (FaN) event from RAC and automatically switches the Application Server's connections and workloads to another Active Cluster node. This reduces total Application Failover Time from over 15 minutes to a few seconds. The figure below captures the High Availability features in OracleAS 10g.



Figure: Oracle Application Server 10g – High Availability

The Workload Management features of OracleAS 10g are designed to provide maximum Scalability and High Availability in a computing grid. These features ensure that Applications run with excellent Quality of Service while using computing resources and capacity as efficiently as possible.

SYSTEMS MANAGEMENT AND MONITORING

Finally, to lower the cost of systems administration and to use system capacity efficiently, it is essential that systems software address the two most important Systems Monitoring and Management challenges introduced by computing grid.

- **Resource Monitoring and Re-Allocation:** Computing resources, such as memory and CPU, need to be monitored actively and accurately to eliminate spare capacity and to make optimal use of existing resource availability.
- **Resource Administration:** Further, Computing Resources need to be managed efficiently and with significant automation to reduce escalating labor costs and error prone human intervention.

Grid computing can make systems management even more challenging due to the scale, diversity, decentralization, and dynamism of resources needing to be managed. However to drastically lower the costs of Systems Management in a computing grid, Oracle has made OracleAS 10g self-managing automating many of the low-level systems management tasks that previously consumed an administrator's time. Further, Oracle has also integrated OracleAS 10g with Oracle Enterprise Manager 10g Grid Control to provide centralized monitoring of servers and to provide centralized administration across many servers.

Status Monitoring: All the services in OracleAS 10g are started, stopped, and managed by the Oracle Process Management and Notification Service (OPMN). OPMN provides automatic death detection and fast restart of these services across a grid. Further, OPMN provides these statistics to Grid Control that can provide summary real-time and historical reports of system availability and outages across a grid.

Performance and Resource Monitoring: All services in OracleAS 10g are instrumented to provide performance and resource consumption information “out-of-the-box” through the Dynamic Monitoring Service (DMS). The statistics generated by DMS are gathered and interpreted by Grid Control along with resource usage statistics from the host operating system. Grid Control provides a rolled-up view of real-time and historical performance of an OracleAS 10g instance, including the aggregate performance of each component in the instance. Administrators can easily identify components that may require diagnostic investigation and drill down into those components for more detailed performance information, such as deployed applications. For instance, the Java Application Server Home Page presents a roll-up of status and performance metrics for the container and its applications, including how long the container has been running and what applications are active; the container resource usage such as the percentage of CPU and memory resources being consumed by various applications; and the volume and average processing time of application requests and transactions. Administrator can easily determine which application is incurring the highest volume of requests or longest response time. An application can be further examined by drilling into the application to view the performance of individual objects such as servlets and EJBs. Using these facilities, an administrator can both have a comprehensive view of resource usage and availability, while quickly and efficiently resolving problems.

Baselines and Policy-based Administration: To reduce the need for labor intensive administration and to allow administrators to intervene to fix systems before problems occur, OracleAS 10g and Grid Control together provide the ability to define administrative policies and to establish baselines for those policies. For instance, an administrator can establish a performance baseline and set thresholds to receive alerts should performance fall below the threshold. Further, the administrator can also establish an optimal system configuration to be used in order to achieve these thresholds. This baseline configuration can then be used as a standard for creation of new systems. Grid Control allows users to easily define policies, to establish baselines for these policies, and to monitor systems for policy violations. Further, Oracle Application Server provides a number of policies out-of-the-box including recommended baselines for these policies. This decreases the amount of time the administrator has to spend diagnosing system problems. **System Notifications:** When a target becomes unavailable or if a policy baseline is violated (for instance a performance threshold is crossed), OracleAS 10g can automatically raise alerts to Grid Control. Grid Control in turn can send notifications to the appropriate administrators via email (including email-to-page systems), SNMP traps, and/or by running custom scripts.

Grid Control supports these various notification mechanisms via Notification Methods. A Notification Method is used to specify the particulars associated with a particular notification mechanism, e.g. which SMTP gateway(s) to use for email, which OS script to run to log trouble-tickets, etc. Super Administrators perform a one-time setup of the various types of Notification Methods available for use. Once defined, other administrators can create Notification Rules that specify 'when' and 'how' notifications should be sent. The 'when' involves specifying the target, its metrics, and the threshold at which an alert should be raised. The 'how' involves specifying which Notification Method(s) to use.

Change Tracking and Management: Administrators sometimes find themselves responsible for figuring out why a system that once worked well is suddenly not performing at an acceptable level. Did someone make a change to a configuration parameter? Apply an Operating System patch? Remove memory? Trying to determine the exact change responsible for the decrease in system performance could take hours if the administrator had to go through each of the possible scenarios manually. This is further complicated by number of nodes in a grid.

Grid Control makes it simple by tracking all changes to hardware and software installations and configurations. This makes it quick and easy for the administrator to view changes that have been made since the last time the machine was functioning appropriately. Further the Application Server's flashback capability allows an administrator to automatically revert the system back to a previous configuration or an appropriate baseline to remedy the problem.

Job Scheduler: Finally, in a computing grid, there are several day-to-day administrative tasks that administrators need to carry out. These include recycling Java VMs to address Garbage Collection issues; restarting Web Servers or Web Caches; and de-fragmenting disks. To automate these tasks, Oracle Grid Control

provides an integrated Job Scheduler that can automatically kick-off specific jobs at specific periods of time on one more systems.

The figure below captures the Systems Management features in OracleAS 10g and Oracle Enterprise Manager 10g Grid Control.



Figure: Oracle Application Server 10g – Systems Management

The Systems Management features of OracleAS 10g and Oracle Grid Control are designed to provide the best Quality of Service with the lowest management cost in a computing grid.

CONCLUSION

Every organization around the world struggles with the very high cost of its information technology infrastructure. These very high costs arise from three primary factors - excess computing capacity; expensive capacity growth; and high management costs. *Grid computing* is a new software architecture designed to effectively pool together large amounts of low cost modular storage and servers to create a virtual computing resource across which work can be transparently distributed.

Oracle Application Server 10g, component of Oracle Fusion Middleware, has been specifically designed to run enterprise applications on computing grids. It is designed to run enterprise applications on pools of low cost servers and storage with very high performance, scalability, and availability while radically reducing the costs of systems and applications monitoring and management.

OracleAS 10g has a number of features designed specifically to enable grid computing including features for Software Provisioning; User and Security Provisioning; Application Management and Monitoring; Workload Management; and Systems Management and Monitoring.

As a result, OracleAS 10g provides customers with three important benefits:

- **Eliminating Excess Computing Capacity:** Through Automatic Workload Management that distributes workloads to use spare computing capacity efficiently.
- **Enabling Modular, Inexpensive Capacity Growth:** Through Rapid and Efficient Software Provisioning that enables computing capacity to be added on-demand in low cost modular units.
- **Radically Lowering Management Cost:** Through Self-Managing systems that reduce the need for costly, error-prone human intervention; and through Automated Software Provisioning and Management across many systems.



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