OVERCOMING CHALLENGES IN MIGRATING TO A CONVERGED INFRASTRUCTURE SOLUTION

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Introduction

Article Overview

This article begins with an explanation of a Converged Infrastructure Solution (CIS), followed by its benefits along with an architectural overview of a CIS. The overall process of migrating servers to a CIS is explained followed by a brief overview of the migration technology. The article then describes challenges experienced from an application owner perspective as well as from the migration team’s perspective. Strategies required for overcoming the challenges are described in detail. Finally, a case study describes how the above mentioned strategies helped in migrating nearly 2300 servers to the CIS for a global pharmaceutical company.

Introduction to a Converged Infrastructure Solution

A CIS integrates multiple, frequently used IT infrastructure components in a single package. CIS components include servers, storage, networking, virtualization, and management. Additionally, a CIS also includes automation and orchestration capability that enables automatic provisioning of the required infrastructure resources. A CIS enables an IT organization to pool infrastructure resources, increase resource utilization, and reduce costs. A CIS is the basic platform for launching cloud services, i.e. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) offerings. From a user’s point of view, a CIS offers rapid elasticity, increased agility, and on-demand self-service capability. From an infrastructure administrator’s point of view, CIS offers ease of cabling and a “single point of control” for administration.

The strong value proposition offered by a CIS has been embraced by IT organizations globally. IDC is projecting that the global spend on converged infrastructure will grow from $4.6 billion in 2012 to a $17.8 billion in 2016 [1]. Several CIS products are available and have been successfully deployed across IT organizations. An example of a CIS is Vblock® from VCE [2].

Implementing a CIS involves standing up and configuring a CIS in a core data center and then migrating all physical and virtual servers from that data center as well as servers from other edge sites into the CIS.
CIS Overview
A CIS consists of primarily five architectural layers including Compute, Network, Storage, Virtualization, and Management. Hardware and software components to realize these layers are integrated into one package.

Ideally, all of the layers are housed in a single cabinet. Cabinets may be added as the storage needs increase.
CIS Architecture

The figure below shows a conceptual architectural overview of a CIS.

At the top are Virtual Machines (VMs). A VM is an image of the physical server complete with the operating system and applications. A VM runs on the Hypervisor which is responsible for sharing the bare-metal hardware across many VMs. It is common to run up to 30 VMs on a single Hypervisor, depending upon how busy the VMs are and the underlying server capacity. The bare-metal server is typically a blade with on-board CPUs and random access memory (RAM). A Storage Area Network (SAN) switch allows the CPU to connect to the Data Store. The Data Store may be realized with various storage technologies including Enterprise Flash Drive (EFD) or Solid State Drive (SSD), fiber channel, and Serial Advanced Technology Attachment (SATA). A network switch allows VMs to communicate with the customer’s network. Convergence comes from the fact that various types of storage including those mentioned above and Network Access Share (NAS) storage are accessed through a common network.
fabric. The VM image(s) reside in the CIS Data Store. Finally, the Management server(s) are used for activities such as configuring the CIS and monitoring the performance of virtual machines, servers, storage, and networking equipment. To simplify management, VMs with a common operating system or VMs running one type of database are clustered together.

**Migrating to the CIS**

The migration process is designed to accomplish multiple activities as follows.

- Virtualize a physical server into a virtual server, i.e. create an image of a physical server. Move a virtualized server image including the operating system and applications running to the CIS Data Store.
- Move an existing VM from a legacy environment to the CIS Data Store.
- When moving a VM, move the associated data files to the CIS Data Store. Files resident on SAN storage and NAS storage will be migrated into the CIS Data Store or NAS.
- Implement networking requirements such as load balancing. Also implement clustering for high availability across virtual machines.

**Migration Process Overview**

In this section, we review the “People” and “Processes” related to migration to the CIS. In the following section, we look at the “Technology” of migration. The figure below depicts three major work-streams involved in the migration process [3]: Discover, Plan, and Execute.
As shown in the figure above, the Migration team collects data regarding servers and infrastructure in the data center. The Migration team can then understand the applications running on each server and any dependencies the server has on other servers. The Migration team assigns migration dates and defines logical groups of servers called “bundles”. Then, the team produces the “Bundling Report” which shows all the servers, applications, application disposition (e.g. virtualize, decommission, etc.), the bundle name to which a server belongs, and a proposed date on which the server should be virtualized and migrated. After reviewing the Bundling Report with the Application Owners, the migration team requests the Capacity Planning team to approve the capacity required. The Capacity Planning team estimates the CPU, memory, and network capacity required to support the server in a target virtual environment. The approved virtualization request is then sent to the Migration Planning team which takes into account the amount of storage that needs to be copied from the source to the target location. The Migration Planning team may adjust migration dates in the Bundling Report based on estimated volume and network bandwidth. The Migration Planning team creates a “migration event list” in which each item identifies the server to be migrated. The “migration event list” is processed by a cross-functional team consisting of Networking, DBA, Virtualization, Storage, and Platform specialists. This process is repeated until the servers are virtualized and migrated to the CIS. During this entire process, if any servers are encountered that cannot be
migrated to the CIS, an exception is created and is reviewed on a case-by-case basis by the Exception Management team.

**Migrating a Server to the CIS**

Migration steps mentioned below are applicable to both physical and virtual servers.

Prior to starting the migration, the application team shuts down the application(s) on the source server. Database service(s), if any, running on the source server are stopped also. Then, the following migration steps are followed.

**Step 1**: A virtualization team member uses the Converter Client and connects with the Converter Server. The source server is left powered on but put into a quiet state. The Converter Server downloads an “Agent” onto the source server (see orange arrow in the above figure).

**Step 2**: Converter server communicates to the Hypervisor and creates a target VM onto the CIS data store (see the green arrow in the above figure).
**Step 3:** The Agent reads from the source server storage and through the Hypervisor in the CIS, writes to the CIS data store (see the blue arrows in the above figure). The CIS Management Network, as opposed to the Production network, is used for this purpose. Therefore, CIS can continue running during this operation. A target VM is created by doing a block-based bit-by-bit copy from the source storage.

**Step 4:** After the target VM creation is complete, the virtualization team member deletes the Agent from the source server.

**Migration Challenges**

The myriad challenges that application owners and migration team members face when migrating servers to the CIS are summarized in this section.

**Perceived Risks**

Application Owners see considerable risk in switching to the CIS platform. Following are the frequently asked questions and the corresponding answers.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Is it really necessary to move my server to the CIS?</td>
<td>Yes, moving to the CIS will result in significant cost savings and benefits.</td>
</tr>
<tr>
<td>2  What’s the impact on the application after moving to the CIS?</td>
<td>For all supported hardware and OS platforms, there should be no negative impact. (Note: If an IP address change is required, it might cause an impact. See #5 below.) Application performance may improve because UCS blade CPU is faster than the legacy server CPU.</td>
</tr>
<tr>
<td>3  I have a business-critical production application. How long will the application have to stay down?</td>
<td>The migration window is 48 hours. The migration team will prioritize critical servers and get them done as soon as possible.</td>
</tr>
<tr>
<td>4  What’s the extent of testing required after migrating to CIS?</td>
<td>“Sanity checking” is required to verify basic functionality. Exhaustive testing is not required.</td>
</tr>
<tr>
<td>5  Will the server name and IP</td>
<td>If a server migrates to a CIS in the same data</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>There is only one CIS in the data center. What if it goes down? How will High Availability be supported?</td>
</tr>
<tr>
<td>7</td>
<td>My server runs Oracle database and the server is heavily used all the time. Is it supported by CIS?</td>
</tr>
<tr>
<td>8</td>
<td>How does application Disaster Recovery work on the CIS platform?</td>
</tr>
<tr>
<td>9</td>
<td>My enterprise application has a Recovery Point Objective (RPO) of 15 minutes and a Recovery Time Objective (RTO) of 4 hours for Disaster Recovery [4]. How will my data synchronization needs be met the CIS?</td>
</tr>
<tr>
<td>10</td>
<td>What will happen if I find that the CPU and RAM capacity allocated to my server running on the CIS needs to be increased?</td>
</tr>
<tr>
<td>11</td>
<td>A few years ago, we attempted to virtualize this server and it failed. Why should I go through it again?</td>
</tr>
</tbody>
</table>

Application owners do not approve a migration to the CIS unless their questions are satisfactorily answered. The migration team has to share knowledge to quell the doubts of the application owners. We will present more about this in the Strategy section of this article.
Server Capacity
After the migration, application owners need their server to be as or more powerful than the current capacity in terms of number of CPU cores, RAM, and storage. Often, the current server is grossly underutilized, but the application owners generally do not want to take any chances with reduced server capacity after migration. This is counter to the principle of providing "just enough" compute power so that the available resources are not wasted. Therefore, the migration team has to navigate through this requirement about capacity.

Secondly, the data center may have some high capacity servers, e.g. servers that need more than 16 CPU cores or more than 256 GB RAM. Such servers require the high capacity blades to be present in the CIS, which the CIS may not be equipped with at the time of migration.

Virtualization Challenges
Migrating purpose-built servers with specific features could be a challenge from a virtualization standpoint. Here is a brief list of cases that will require investigation before they are migrated into the CIS.

• Special purpose hardware for application needs: Examples include servers that must use a voice card or a fax card for processing incoming voice or fax signals.
• Special purpose peripheral hardware for licensing: Some application owners require that the server must have a dongle in the USB port for the software license to work.
• Application vendor non-compliance with virtualization: Certain application vendors may not support an application if it runs on the virtual server platform. Consider the case of a security application running on a server that caters to thousands of desktop/laptop clients. The security application vendor may not have tested the application on a virtual server and will not guarantee the required response time, if the application does not run on the recommended physical platform.
• Older operating system versions: Older versions of an operating system, e.g. Red Hat Linux version 2.1 may not be supported by the CIS Hypervisor. An upgrade will be required before virtualization.
• Clustered servers with shared disk: Consider clustered physical servers sharing a disk. Investigation will be required to understand how clustering will be supported by the CIS virtualization layer before migrating to the CIS.
• Large Capacity Servers: It may be challenging to support servers that need more than four Network Interface Controllers (NICs), more than 10 TB of storage, or more than 16
CPUs. Due diligence is required to confirm that such servers can be migrated into the CIS.

- Unique File Systems: Most CIS products will support servers which are running NTFS [5]. But, what if a server is running VxFS [6]? A confirmation that CIS will support the file system is required before deciding to migrate it into the CIS.

**Limited migration window**

Typically, migrations are performed during off-business hours, i.e. in a 48-hour window starting Friday 5 PM through Sunday 5 PM. Time required to migrate largely depends upon the amount of storage that needs to be copied. Bigger the storage, the longer it takes to migrate. For servers located in edge sites, in addition to the storage size, the available WAN bandwidth between the edge site and the core site where the CIS is located determines the time required to migrate a server. Obviously, less WAN bandwidth means longer time to migrate.

**Special Architectural Requirements**

Certain servers need extra effort from a planning and design standpoint before they can be migrated into the CIS. For instance, clustered servers, servers that need load balancing, etc. Suppose a server talks to peripheral devices over a 100 Base T interface. Careful analysis is required to ensure that this interface will work correctly after virtualization.

**Licensing Constraints**

It is common to license an application to work on a server with a specific CPU or a specific CPU count. Such a constraint needs to be amended prior to migration to the CIS. Secondly, the license manager may check that the current MAC address is the same as when the license was purchased. If the MAC address does not match the original value, the license manager does not let the application start up. Fortunately, the MAC address can be retained after virtualization but such license constraints need to be analyzed prior to migration to the CIS.

**Scheduling Changes**

From a migration team’s perspective, changes made to a previously agreed upon migration schedule is a big challenge. Suppose that a server is scheduled to migrate. However, just prior to the migration date, the application owner finds a reason for not going ahead with the migration. For example, the application owner determines that the development team is trying to reach a critical milestone and the 48-hour migration window will have a big impact on the development schedule. Or the application owner requires the virtualized server to have the
same CPU and memory capacity as the physical server before they can approve the migration. Such schedule disruptions make it harder to reach the goal of completing a pre-determined number of migrations within a certain timeframe.

**Strategies**

The following drawing broadly depicts strategies that will help overcome migration challenges previously described.

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**Directive from Leadership**

Senior leadership at the CIO level should make it clear to the IT rank and file and the relevant business stakeholders that migrating to the CIS is not optional; it is a strategic move that reduces costs for the enterprise. Senior leadership should communicate the benefits of moving to the CIS and should identify the scope of the migration activity, e.g. “All physical and virtual servers running Windows 2000 (or above) or Linux 3 (or above) shall be migrated to the CIS unless an exception is granted by the Exception Management Team.” Such a statement is vital for gaining support for the migration team’s efforts.
Knowledge Sharing

Application owners have a lot of questions about CIS and will not approve the migration until those are satisfactorily answered. Therefore, right after the migration program is launched, organize presentations and discussion sessions to address migration related questions. Topics such as high availability and disaster recovery should be discussed with subject matter experts so that the application requirements are analyzed correctly. Hold periodic meetings to provide updates about the number of servers satisfactorily migrated. A newsletter, a corporate web site, and a collaboration portal dedicated for migration efforts are effective tools for sharing knowledge about the migration benefits, migration schedule, and migration completion metrics.

Before the migration event, the migration team should review all migration specific requirements with the application owners. Keeping the application owners informed through periodic workshops will ease schedule and conduct migrations.

CIS Build-Out Strategy

Before launching the migration effort to migrate servers into the CIS, a requirements gathering exercise should be conducted to understand the service patterns applications require from an infrastructure platform standpoint. Primarily, CPU and storage needs as well as high availability and disaster recovery requirements should be clarified through such an exercise. Create a roadmap to show how the CIS capabilities will evolve over time.

It is easy to start with a basic CIS configuration and then add certain features as you go. For instance, for the first 6 months after the CIS is operational, it may not have high performance server blades. Servers that need less than 16 CPU cores and less than 64 GB memory will be migrated in the first 6 months. Eventually, high performance blades are added and migrations of high capacity servers are begun. A sample road-map is shown below.
**Migration Scheduling**

From a risk mitigation standpoint, migrations to the CIS should be scheduled with the following best practices in mind.

- Schedule migration of non-critical environments first before migrating production, i.e. migrate “Development”, “Test”, and finally, “Production”. For example, migrate the Development server first and two weeks later, migrate “Test”. Schedule “Production” to migrate 2 weeks after “Test”. This phased migration approach will build confidence of application owners that the migration will run smoothly.

- If an application is running on multiple servers, all the servers should be scheduled to migrate together as part of one migration event.

- Be prepared to roll-back a server to its original physical or virtual form should issues appear during virtualization or migration.

- If there are multiple servers performing a critical function that serves all the servers in a data center, e.g. “Domain Controllers”, do not migrate all of them in one event; stagger their migrations over multiple migration events.

- A migration should not be planned unless an explicit, written confirmation from the application owner is received. The confirmation should also include an acceptance of the target server specification.

- License issues regarding migration to the CIS should be worked out with the application vendor before the scheduled migration.

- Maintain a pipeline of servers that can be scheduled for migration. That way, even if some servers drop out of a specific event or some servers cannot be scheduled due to licensing constraints, they can be replaced by servers in the pipeline.

**Capacity Planning and Target Server Sizing**

Standalone servers typically run at 10 to 20% of the capacity as far as CPU and RAM are concerned. The objective of virtualization is to share the resources across multiple servers and run the CIS server at 70 to 80% of the capacity. Before a server is migrated to the CIS, it is necessary to determine the utilization pattern. To help determine server utilization, there are various capacity analysis and planning tools available [7] [8]. For example, VMware Capacity Planner is a tool that polls a server to collect average, prime time, peak, maximum, and minimum utilization for processor, memory, disk drive, and network resources. Utilization is determined by collecting multiple samples each hour of the day for each week. Statistics for
each hour are correlated together to determine the utilization. As an example, the following chart produced by the Capacity Planner shows peak CPU utilization (about 25%) occurring at 3 points in a 24-hour period and the average utilization of about 8% over a 24-hour period.

![CPU Utilization Chart](chart.png)

Capacity Planner also recommends the optimal level of resources required for the server to support peak load. Challenges associated in using Capacity Planner to estimate resources include:

- Capacity Planner needs to observe server utilization for a period of three weeks before it can make a resource recommendation. In essence, the migration team needs at least three weeks of measurement before it can migrate the server to the CIS.
- Capacity Planner may not be able to report the true utilization for certain servers. For example, consider a failover server which is supposed to take over from a primary server. It remains idle unless it has taken over from the primary server.
- For certain servers, workload spikes during specific periods, e.g. end of the month, quarter, or year. If Capacity Planner does not poll the server when the "end of the period" spikes occur, it does not reflect the true load on the server.

Considering the above challenges, it is a good idea to make certain exceptions to Capacity Planner recommendations and not implement the recommendations verbatim. Further, in order
to overcome objections from application owners, drastic reductions in CPU and memory resources are avoided and the following guidelines are suggested.

1. The number of vCPUs in the target server will not be less than 50% of the CPUs in the original physical server. Consider the following example. Original server has 4 CPUs. Capacity Planner recommends 1 CPU. The target server in the CIS will be provisioned with 2 CPUs.
2. For a database server, a minimum of 4 vCPUs will be allocated in the CIS.
3. Memory allocated to a target server will not be more than the memory allocated to the physical server and memory will be allocated in 4 GB increments.
4. For the sake of simplicity, virtual servers will be migrated on an “as-is” basis, i.e. there will be no change in the CPU, Memory, Storage, and Networking specifications when a virtual server is migrated to a CIS.

Here is a real-life example. After Capacity Planner observed the performance of a physical server with 8 CPUs and 64 GB RAM, it determined that the CPU utilization was 49% and the RAM utilization was 90.45%. Based on that observation, Capacity Planner recommended reducing the number of CPUs to 4 and increasing the RAM to 84 GBytes in the target processor in the CIS. However, with the above guidelines in mind, the target server was configured with 4 vCPUs and 64 GB vRAM. The server is running fine and no performance issues have been observed.

**Migration Design**

Migration design is about making sure that:

- Target server will meet all the interface requirements as the source server
- Target server will perform equal or better than the source server
- Target server meets all the configuration requirements, such as load balancing

Further, migration design also ensures that there is no adverse impact on the business during the migration window. For example, consider the case of a payroll server for which a failover server does not exist. The payroll server polls time-clocks over a 100Base-T interface. In this case before the server migrates, the migration team needs to make sure that the 100Base-T interface will be supported by the virtual server. Second, a design solution is needed to ensure that employees can use time-clocks as usual and data entered while the migration is in progress.
is not lost while server migration is in process. The design solution should be reviewed and documented so that the execution team will be able to follow it during the migration event.

**Migration Performance Measurement**

Migration performance measurement helps the migration team estimate the time required for migration. Application owners often want an estimate of how long it will take to migrate their server. By keeping a log of the time required to migrate a server, the migration team will be able to estimate the migrations with a greater degree of accuracy. Also, logging the time required to migrate enables the migration team to come up with ideas on how to reduce the time required.

The following formula shows how migration time is calculated.

\[
T_m = t_1 + t_2 + t_3
\]

Where, \( T_m \) = Total time required to migrate a server.

- \( t_1 \) = Time required to copy from source to target server. The value depends on the used storage size for the source server and the available network bandwidth used when copying from the source to the target.
- \( t_2 \) = Time required to do networking changes, independent of server size.
- \( t_3 \) = Time spent in any housekeeping tasks such as deleting temporary files, etc., independent of server size.

The following chart shows the actual time taken to migrate servers of various sizes. As expected, the bigger the server, the longer it takes to migrate.
**Migration Tools**

The goal of the migration team is to complete a migration with minimal application downtime. In addition to off-the-shelf migration tools such as VMConverter [9] and PlateSpin [10], several other approaches are possible.

**Swing Storage**: The Swing Storage technique speeds up the migration of a virtual machine (VM) from a legacy data store to the CIS. As shown in the figure below, Swing Storage is NAS-mounted and is accessible from the legacy side as well as from the CIS. Under the control of the legacy Management server, the VM is moved from the legacy data store into Swing Storage. In the next step, under the control of the CIS management server, the VM is moved from the Swing Storage into the CIS data store. If the legacy data store is not in the same data center, two Swing Storage arrays can be set up and replication software such as Open Replicator [12] may be used. Physically moving, i.e. not copying, the VM works faster than going through the Converter server, saving migration time.
**Concurrent Migrations:** If concurrent Swing Storage sessions can be created, multiple VMs can be moved simultaneously from the legacy data store(s) to the CIS data store, saving time.

**Converter Sync Option:** What if the application owner cannot keep the server down longer than the typical migration window of 48 hours? There are tools such as VMware VMConverter with the “Sync” option or DoubleTake [11] that copy the source VM to the target VM and, if the source VM changes, make the same change in the target VM. Thus both the source and the target VM remain synchronized.

**Exception Management Process**
When a server cannot migrate to the CIS, an exception should be recorded and each such exception should be reviewed and tracked by the Exception Review Board (ERB). Valid causes for an exception include:

- Peripheral, e.g. server needs a voice processing module
- Cluster requirement that cannot be met within CIS
- Future Capability, e.g. server needs 32 CPUs which cannot be provided now
- Vendor Non-Compliance, e.g. vendor does not support application on a virtual server

During the exception review, cases often come up during which application owners and vendors cite issues they have had with virtualization a few years ago. If an application vendor does not comply with virtualization, ERB should push back on the application vendor to certify the application on a virtual platform. ERB should emphasize that virtualization technology has made great strides in recent years and issues that occurred in the past should not be used as a reason for not virtualizing the server. IT Management should make it clear that unless an exception is approved by ERB, all servers that meet the basic platform criteria, e.g. x86 servers running either Windows or Linux, must migrate to the CIS.
Case Study

A global pharmaceutical company with four data centers—one in Asia, one in Europe, and two in the U. S.—has adopted Vblock as the CIS. Nearly 2300 physical and virtual Windows and Linux servers have been migrated across all four Vblocks over a period of 10 months in 40 migration events. Migrated servers include heavily used Oracle and SQL Servers as well as Web application servers. The applications that have migrated include mission-critical financial, HR, manufacturing, and R&D applications. Strategies and best practices mentioned above have been used during migrations.

Issues arising in each migration are reviewed after each migration event and the migration process is improved based on lessons learned. Because of careful planning done prior to migration including allocation of vCPU, vRAM, and networking resources, servers are working at a performance level equal or better than the original server. We have not come across any applications that required changes due to migration. In most cases, the IP address did not change due to migration. For about 50 applications, the MAC address had to be retained after migration. Nearly 10 servers had to be rolled back. About 20 exceptions have been approved because of reasons such as a dongle is required or a fax processing card is required to be present in the server.

A rigorous exception management review has been implemented to track exceptions. As a consequence of migration activities, an entire data center has moved into a much smaller room directly leading to savings in real estate rental costs and energy costs. In many cases, after the migration team started talking to the application owners about scheduling a migration, it became clear that the server was no longer needed and should be retired. Close to 1400 server retirements have resulted in savings in space, energy and license costs.
Conclusion
The table below summarizes how various strategies can be used to overcome challenges that arise during the migration process. This does not imply that these are the only challenges that will come up. It is hoped that readers of this article will be better equipped to handle these and other challenges that might come up on their way to a successful CIS migration.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Perceived Risks</td>
<td>Directive from Leadership, Knowledge Sharing, CIS Build-Out Strategy, Migration Scheduling</td>
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<td>Migration Scheduling, Exception Management</td>
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<td>Performance Measurement, Migration Tools</td>
</tr>
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<td>7 Scheduling changes</td>
<td>Migration Scheduling, Server Capacity, Exception Management</td>
</tr>
</tbody>
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References


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