Reduce Costs and Risks for Data Migrations

Data Migration Best Practices and Nondisruptive Migration Service Capability for Enterprise Storage

By Hitachi Data Systems
March 2014
Contents

Executive Summary 3
The Importance of Data Migration 5
Description of Enterprise Storage Migration Survey Model 5
Key Risk Factors for Data Migrations 6
  Unexpected or Extended Downtime: Organizations Always Need to Have Their Information 7
  Schedule Overrun: IT Project Management 8
  Budget Overrun 8
  Customer or Brand Impact 8
Key Cost Factors for Data Migration 8
  Change Control or Remediation 9
  Server or SAN Outage Cost 9
  Application Outage Cost 10
  Labor for Data Movement or Migration 11
  Specialized Hardware and Software for Migration 11
  Added Environmental Costs 12
  Useful Life Impact on Storage System 12
  Storage System Maintenance 12
Combine People, Processes and Technology to Reduce Data Migration Cost and Risk 13
  Hitachi Data Systems Migration Center of Excellence (MCoE) 13
  Migration Methods 13
  Storage Virtualization Approach 15
Lower Risk With Experience and Methodology Based on New Technologies 20
  Best Practices and Lessons Learned From Successful Data Migrations 21
Conclusion: Develop Comprehensive Strategy to Reduce Both Cost and Risk 23
Appendix A — Survey Demographics 24
Appendix B — Calculation of Data Migration 27
Appendix C — Survey Results: Direct Costs 29
Appendix D — Cost Analysis 31
Appendix E — Survey Results: Best Practices From Successful Data Migrations 32
Appendix F — Hitachi Data Systems Data Migration Methodology 33
Reduce Costs and Risks for Data Migrations

Executive Summary

"Migrations represent 60% of all large enterprise IT projects, and only 60% are completed on time," according to IDC1. Meanwhile, nearly half of enterprise IT budgets are devoted to operating costs, per 451 Research2. Organizations need to accelerate innovation and reduce operating expenses to increase their competitiveness or maintain their current market position. CIOs are under pressure to identify and adopt best practices to lower their IT operating expenses and redirect the savings in support of new investments, initiatives, and IT as a Service.

Major drivers of growing data center operating expenses include ongoing power, cooling and labor costs. IT organizations are in a constant flux, handling change management due to storage growth, consolidations, mergers and acquisitions, vendor product life cycles, and interoperability and supportability requirements. For example, most enterprise IT shops have to plan for their storage platforms' end of life and migration before the end of the 4 to 5 years of the storage products' useful lives. This white paper is intended to provide IT decision-makers with information on costs, risks and considerations regarding the migration of data from old storage platforms to new storage to reduce this significant area of operating expenses.

To understand the strategies and best practices organizations were using to reduce cost and risk with storage migration, Hitachi Data Systems leveraged a survey, in partnership with TechValidate. HDS worked with the independent market research firm to build a working model as a framework for assessing the feasibility of the different migration capabilities. The model also considered the risks and costs associated with the various options. Key findings from the survey that illustrated the expense of migration and best practices to reduce the cost and risk include:

- Migration project expenditures are on average greater than 200% of the acquisition cost of enterprise storage. With an average of 4 years useful life, the annual operating expenses associated to migration represent >50% of acquisition cost.
- Enterprise storage migration costs can exceed US$15,000 per terabyte migrated.
- Storage migration projects required 4 to 6 hours per host, from internal organization resources. Of these hours, 4 to 5 hours were used to plan the migration and 1 to 2 hours (~30%) were used to execute the migration.
- Duration of the migration is mainly due to limited maintenance windows. Common migration techniques require application outages due to either SAN rezoning and/or host reboot activities.
- The 2 biggest concerns that organizations face during data migrations are:
  - The risk of downtime or extended downtime and impact to the business.
  - The budget overrun of the migration project.

A full 70% of customers reported schedule overruns of about 30% while 64% reported average budget overruns of 16%.

- The leading indicator of schedule and budget overruns was the team member experience.

---

1 IDC Storage and Data Migration Services Overview, November 2013
2 InfoPro Storage Wave 17, 451 Research, 2013
Organizations are spending considerable resources and assuming more risk than necessary to conduct data migrations. There are many new approaches that greatly reduce cost and risk, including using virtualization, cloud migrations and the capability to nondisruptively migrate data. To successfully migrate data with these new approaches, enterprise IT executives should leverage a vendor who understands all of the approaches and has experience migrating various platforms with multiple technologies. Hitachi Data Systems has dedicated a unique set of services through its Migration Center of Excellence (MCoE). We employ a broad portfolio of hardware, software, best practices, framework, processes, people and services. Our experience with all industry-leading software and hardware helps organizations to reduce risk and costs for their data migrations now and for the future. Also, Hitachi virtualization capabilities enable storage controller-based nondisruptive migration between Hitachi enterprise storage platforms and from most competitive storage platforms to Hitachi platforms. It enables organizations to completely eliminate the outage window due to data migrations, upgrades, moves and technology refreshes.

By reducing risk and costs for data migrations, organizations will reduce operating costs due to data migrations and more easily prevent technological obsolescence. Enterprise IT executives can use the ideas in this paper to research this topic further to understand how much data migration costs their organization. These costs will only increase. Hitachi Data Systems expects the industry average cost of enterprise storage migration to continue to rise due to increasing 24/7 application availability requirements and increases in cost of labor. On the basis of this research, it is highly recommended that IT executives evaluate new storage platforms in conjunction with migration solutions to lower data center operating expenses.
The Importance of Data Migration

Data migration is an important event that consumes significant budget and labor, and occurs very regularly. The combination of the frequency of and resources consumed in a data migration results in data migration taking a significant amount of the IT budget. As storage infrastructures become larger and more complex, data migrations are becoming more complex, risky and labor intensive. Organizations must begin managing this growing portion of their IT budgets more effectively.

While organizations are continually migrating data, they are not considering data migrations a core competency. Data migration is usually the result of another event in the data center, such as an application upgrade, data center consolidation project or technology refresh. According to a 2010 survey conducted by ESG3, more than 1/3 of respondents currently have data center reduction or consolidation activities in progress.

Data migration projects can be very complex, with large-scale projects requiring many in-house and contractor personnel. As a result, the labor, consulting, software and hardware for data migration have become a very large market. The overall market for data migrations can be calculated by identifying the amount of data migration activity that results in large data migrations. Many data migrations are a result of technology refreshes. For example, an average enterprise company has an average of 1,400TB of network attached storage (NAS) and nearly 8PB of storage across their storage systems4. As the useful life of most storage systems is 3 to 5 years, this size of organization will often, at any given time, have multiple storage systems at the end of their useful life spans and requiring a refresh. In fact, nearly 40% of the organizations surveyed plan a technology refresh in the upcoming year, up from 26% the year before5. Therefore, these large enterprises could be in a position where they would be always conducting a data migration of multiple storage devices at any given time.

We can assess the overall market for data migrations as a result of these storage technology refreshes by using the overall storage market revenue. In 2012, it was nearly US$9 billion, with that number expected to increase in 2013 and 2014 (for storage systems > US$150,000) and data from our survey model. Data from our survey indicated that when all the labor, resources and equipment required for conducting a data migration are included, the cost of the data migration was twice that of the acquisition price. Therefore, the overall data migration market would be US$18 billion in operating expense to support storage technology refresh in 2012, with that number expected to rise in subsequent years. This type of market size indicates a very large operating expense; organizations should focus more attention on defining best practices and technology to reduce this large expense.

Description of Enterprise Storage Migration Survey Model

In all cases, the statistics and numbers referenced in this document are not to be used as guidance; consider these findings as an industry average, which fluctuates based on sampling frame. Changes in size of respondent organization, industry, geographic location, and labor cost and migration technique selected are just examples of factors that influence migration project statistics. Hitachi Data Systems did not force an equal sample of respondents for each migration technique. Therefore, comparisons between migration technique (as shown in Figure 1) are limited to host and virtualization migration techniques only; the number of observations was too low for the other techniques to make a valid comparison.

---

4 Source: InfoPro Storage Wave 17, 451 Research, 2013
5 Source: InfoPro Storage Wave 17, 451 Research, 2013
In the sampling frame for this research were respondents who have storage responsibility (from CIO to storage administrator) and were part of an enterprise organization (>1,000 employees US companies, >500 employees non-US-based organization); 50% were Hitachi Data Systems customers and 50% were non-Hitachi Data Systems customers. The respondent organizations were located within countries that were English (reading) proficient (for example, United States, Canada, UK, Germany, Switzerland, Belgium, Australia, New Zealand, Singapore, and so forth).

Respondents’ industries and sizes of migration projects (in terms of size of data set migrated, number of storage frames and number of hosts impacted) were widespread. For a detailed breakdown of respondents, go to Appendix A — Survey Demographics.

Considering that respondents reported an excess of 70% of the storage migration cost is driven by labor cost, it is important to factor in the full time equivalent (FTE) costs reported in this research of US$126,000 in contrast with IT average labor cost for an industry or organization. FTE cost does not equal employee salary; frequently, an organization’s FTE cost may be closer to a ratio of 1.25 to 1.5 times the employee salary. This salary-to-FTE ratio varies based on organization overhead and geographic disparity in social benefits. For a more detailed breakdown of the wide range of reported FTE cost, go to Appendix A — Survey Demographics.

**Key Risk Factors for Data Migrations**

Data migration projects are critical to the success of the initiatives that the migrations support; they impact business-critical data, applications and systems, and result in significant cost. The data migration project itself possesses...
significant risks and requires proper planning and attention to ensure success of the data migration and the initiatives that it supports. Such initiatives may range from an enterprise-wide application upgrade or data center consolidation to an infrastructure upgrade.

However, as mentioned earlier, IDC indicates that many organizations do not place the proper importance on and take proper consideration of the data migration. Only 60% of migration projects are completed on time and 60% of all IT projects include migrations. Therefore, it is more important than ever to plan accordingly and complete them on time and within budget.

In our survey research, survey participants identified many risks for data migration projects, as indicated in Figure 2.

**Figure 2. Perceived Risks in Migration Planning**

![Perceived Risks in Migration Planning](image)

We will focus on a few key areas of risk for data migrations: downtime or loss of data, schedule overrun, budget overrun and customer or brand impact.

**Unexpected or Extended Downtime: Organizations Always Need to Have Their Information**

Very detailed and careful planning is needed to clearly identify windows in which downtime is acceptable and ensure that no data is lost. For data migration projects that include mission-critical business data, the risk of impacting sales operations is high; the loss of availability or access to the data could directly impact the profit and loss of the business.

Trends in compute architectures and the adoption of virtualization have increased the number of applications running on a single host. This has resulted in decreasing maintenance windows where the downtime to a host can result in multiple significant application outages. Figure 3 illustrates the increasing density of applications due to virtualization and adoption of multicore computing architectures.
Schedule Overrun: IT Project Management

According to the participants in our survey model, only 64% of data migration projects were completed within 10% of the planned date. When data migration projects last longer than planned, resources are used for longer than anticipated. The schedule overrun can also impact or delay other planned IT projects and impact the business. Often, data migration is part of a larger overall project, and the delay in the data migration project affects the success of the larger overall project.

Budget Overrun

As with all IT projects, a significant risk is the cost associated with any budget overrun. This can directly affect budgeting for other IT projects and, therefore, affect the profit-loss statement for the business. As identified previously, data migrations are part of a larger project. The budget overrun of the data migration project reduces the overall cost per benefit for the larger overall project.

Customer or Brand Impact

Data migration projects can involve customer business data. If any of that data is lost or a customer’s access to the data is interrupted, there could be a very severe negative public relations impact. The trend is for organizations to have more interconnected applications among customers, suppliers and partners. Downtime in one application affects multiple applications and increases the magnitude of the negative impact of a loss of data or availability of data. Also, there could be legal implications and revenue impacts for the loss of data or availability of data.

Key Cost Factors for Data Migration

Storage Economics from Hitachi Data Systems is a methodology to identify, isolate, characterize and measure costs (of storage) so that actions can be taken to reduce total costs. Within these methods, Hitachi Data Systems has defined 34 different types of costs that apply to storage total cost of ownership (TCO). Some costs are hard costs, which means they directly impact budgets and expenditures. An example of a hard cost would be power and cooling costs for storage systems. This hard cost is a real cost that appears in the IT organization to provide power. Soft costs, on the other hand, are quantifiable but may not produce tangible results in a budget. Reducing a storage management action may save an administrator 2 hours of work. Although the savings of 2 hours has many benefits, the administrator would not be paid any less due to this change.
Storage costs are also highly dependent on the organization that pays for the cost. Not all costs are simply rolled into a single management budget. Rather, they are often spread between several organizations. The distribution of costs can sometimes add to the softness of savings to be measured. Best practices in cost reductions tend to occur when an "economic hero" emerges to take ownership and provide common cost metrics for the entire organization. These econometrics can provide the stimulus for continuous improvements as costs are consolidated, measured and used for future actions or improvements.

Since 2002, Hitachi Data Systems Storage Economics methods have provided a characterization framework of various hard and soft costs associated with storage system migration and data remastering. The determination of hard or soft, or the direct or indirect nature of migration costs, is a decision left to the organization. The following sections outline the nature of the cost of migrations without necessarily attempting to quantify each element; that is left to the reader to calculate based on local parameters. These sections identify cost estimates based on analysis of the survey results where participants were able to provide valid data.

Change Control or Remediation

Change control, version control and configuration management tasks are integral functions with all IT organizations. When a storage system reaches end of life or is fully depreciated (or its lease ends), there are certain fixed tasks associated with planning the move and removal of the old asset. Further, there are tasks associated with absorbing the new assets, including porting of existing software utilities and scripting to the new environment. Testing, certification and verifying the new assets aside, several operational tasks are essential to replacing any hardware. Microcode, interoperability, security and operating system alignments are just some of the necessary tasks involved with change control and configuration management.

To the extent that the tools and methods used to complete the migration are limited (assets besides those being replaced or introduced), most migration methods consume roughly the same change control effort, time and cost. If the migration effort requires new appliances, tape resources or specialized software to enable the migration, then the added effort with these tools needs to be factored into the total migration cost.

In the Enterprise Storage Migration survey model, survey participants identified how much effort was required to perform remediation activities and migrate existing scripting to the new storage environment. To enable organizations to use the results of the survey to develop their own rough cost models, the analysis of the costs from the survey are documented in costs per terabyte. This allows organization to tailor this data to their environment. Using the cost of labor identified by survey participants and the cost of external consulting services, Hitachi Data Systems calculated the total cost for remediation and scripting: US$6,733/TB. The breakdown of this total amount was: for remediation, US$4,965/TB, and for scripting, US$1,767/TB.

Server or SAN Outage Cost

In most migration methods or processes, the servers need to be rebooted to end the connection with the old storage system and to be re-established with the new resources. As a target to the server, the storage may present LUNs to many applications on the server, so a single server outage usually involves secondary impact to application outages (see next section: Application Outage Cost).

Each server reboot has to be carefully scheduled, usually in low usage times on the weekend, and often has to be planned well in advance of the actual outage. High-availability server clusters or virtual machines require special time and attention to this detail. Some operations require a server reboot only during scheduled maintenance windows, which may or may not align with the storage migration timetable. New business demands are constantly shrinking or eliminating server outage and maintenance windows.
The cost or impact to the business of the server outage may be hard to calculate and is a function of the business revenue or operation costs of the servers’ applications being offline. If scheduled during a routine maintenance window, these outage costs are minimized (planned and expected). But if they are outside of this window, the business impact can be measured in terms of lost revenue, opportunity loss or business disruption costs.

Ideally, new migration methods that reduce or eliminate server and SAN outages will enable continuous business operations. Eliminating server, SAN and application outages is a primary economic benefit of migration techniques that keep continuous operations intact. Figure 4\(^6\) provides a rough measure of the massive impact downtime can affect by industry and specific applications within those industries. The figure shows distribution of total cost for 15 industry segments computed from 67 benchmarked data centers.

Figure 4. Distribution of Total Cost for Industry Segments

![Figure 4: Distribution of Total Cost for Industry Segments](image)

Application Outage Cost

Just as in server outages, some applications may be impacted with a change in storage resources.

Similar impact to applications can be drawn from the above description of server outages, in terms of:

\(^{6}\) Source: 2013 Cost of Data Center Outages, Ponemon Institute, 2013
- Scheduling within an approved maintenance window.
- Impact to the business when the application is offline.
  - Opportunity loss cost and revenue lost.

Migration methods that can be achieved without disrupting servers, SANs, applications and databases are far superior to other methods because of the lightweight impact to business and IT operations.

Labor for Data Movement or Migration

Data migration requires human intervention. From planning and change control through the data movement and server or application restart process, there are several levels of staff labor and effort. This section highlights the often-tedious methods of planning, copy, move and verification tasks that are required to be completed by the IT staff and/or external consulting resources.

Sometimes, due to time constraints and other priorities, some migration tasks can be outsourced to 3rd-party agencies that will perform much of the heavy lifting involved with data migrations. Therefore, the costs of migrations must be viewed and tracked for internal and external consulting costs.

Costs of labor vary widely from region to region around the world. When calculating internal costs of migration labor, the administrator’s salary can be used. However, there must be an addition of a 50% overhead (office space, insurance, tax) or burden factor to determine the true costs associated with the tasks. Nights, weekends and overtime rates are common for nonexempt personnel and need to be factored into the costs of migration.

Advanced methods of data migration (utilizing virtualization techniques) can reduce the labor time and effort drastically. The arduous tasks of copy and move are often automated to the extent that the administrators can assign the target devices and allow the system to move and migrate in the background. With nondisruptive migration (NDM) capability from Hitachi Data Systems, organizations are able to completely eliminate the outage window. The NDM core technology is a persistent identity feature of Hitachi enterprise storage platforms, which enables spoofing of a source logical device SCSI identity. This virtualization feature is transparent and agnostic to any modern operating system or hypervisor, host, path management, host clustering and SAN networking. Once the source volume identity takeover is performed, the target volume will appear as an alternative path to the original volume in all aspects, including the device, serial number, port and worldwide name identifier. The host discovery, review and planning phases of the migration are still required; in large enterprises it is possible to have a host connected to several storage frames. The NDM service capability enables a simplified and nondisruptive migration, which is 90% less effort and cost compared to the industry average.

In the survey model, the participants identified the following costs for the labor effort necessary to conduct the migration. The participants identified both internal staff and external consulting costs. The internal IT staffing cost to conduct the migration was US$2095/TB and the external consulting cost was US$3552/TB.

Specialized Hardware and Software for Migration

Another factor of traditional migration methods is the introduction of specialized tools or appliances to complete the migration. These can be purchased, leased or used for one-off migrations. Larger organizations that are in a state of continuous migrations make long-term commitments to these tools and appliances to meet the constant demand. Examples of these specialized tools include:

- Swing hardware (storage, virtualization appliances) that serve only to move data from system to system.
- Backup systems (hardware and software) including tape media.
- Copy and replication software.
- Additional SAN or network devices (ports) to support the data movement process.
- Dedicated network circuits.

Survey participants identified that the cost for hardware and software to assist with the migration was US$5,099/TB.

**Added Environmental Costs**

A cost (hard cost) that is often overlooked is the additional floor space and power and cooling costs associated with storage-system-based migration. When migration efforts take 3 to 9 months to complete, environmental costs associated are doubled, since both the old and new storage systems are running side by side for that time. Calculating the total environmental costs during a long migration period requires adding the power, cooling and floor space costs for the new storage system for this period. Data centers that are limited with power or space will experience secondary costs since long migrations will consume power and space resources that could otherwise be used for operational growth or strategic IT investment.

**Useful Life Impact on Storage System**

One of the soft costs associated with long migration times involves reducing the useful life of the storage asset. When looking at the time involved with migrating data onto and then removing data off the storage systems, the actual useful life of the storage system is greatly diminished. It is not uncommon to see the asset’s useful life negatively impacted by 20% to 33% due to the time and effort involved with migration. Reduction in the useful life has a direct impact on the return on asset (ROA) for the storage assets and the entire IT organization. Long migration times result in overlapping assets and costs to the organization that are not necessary, especially when techniques and methods exist now to nearly eliminate migration impact.

**Figure 5. Assessing the Storage Asset’s Useful Life**

Using the survey data model, we were able to calculate that the useful life impact costs for the storage system in the average data migration for the survey participants was US$236/TB. This calculation is introduced in the Cost of Migration Comparison section below and explained in Appendix D — Cost Analysis.

**Storage System Maintenance**

We often see that the migration process does not get started until the end (or near end) of the asset warranty period. Extending the terms of the hardware and software maintenance to cover the period of migration is a hard cost.
Combine People, Processes and Technology to Reduce Data Migration Cost and Risk

Data migration projects are complex projects that possess significant cost and risk. To successfully complete a data migration project, organizations must develop a comprehensive plan encompassing people, processes and technology.

Hitachi Data Systems Migration Center of Excellence (MCoE)

The Hitachi Data Systems Migration Center of Excellence comprises a team of people, supporting tools, services, methodology, best practices, partnerships, go-to-market and business development around migration focus area to drive business results. The MCoE value to organizations is a combination of services framework, expertise and best practices for solving customers’ business problems and addresses a comprehensive set of domains such as:

- Solution approach.
- Partnerships.
- Service offerings.
- Thought leadership.
- Methodology.
- Flexible delivery.
- Tools.
- Expert resources.

MCOE’s comprehensive approach helps bring the right set of services, tools, partnerships and expertise to solve problems and provide premium value to organizations. The MCOE approach, by design, provides engagement flexibility. It helps to support or to own and manage complete IT transition (from strategy definition to deployment and operation) in partnership with the customer team. Together, they create a future-ready IT infrastructure, driving business forward.

- Hitachi Data Systems Migration Center of Excellence creates unique model to capture and deliver best practices, standardization, re-use and productivity. It provides for fast and efficient migration of data to new architectures and operating environments. The model creates a centralized service that consolidates migration services in into 1 unit, with a focus on standardization to leverage benefits of economies of scale. The center of excellence model introduces new processes or services with proven methodologies, best practices and tools to deliver predictable outcomes consistently. Examples include: standardized tools and processes for project effort estimation, as well as assessment, architecture and migration techniques for infrastructure consolidation leveraged across all projects.

- Our open technology and collaborative approach means HDS solutions integrate with your existing environment to help you get the most out of all your investments. Engaging Hitachi Data Systems Services helps you leverage deep expertise, collaborative and jointly defined and validated reference architecture best practices. You work with our partner ecosystem, which includes Microsoft, VMware, Oracle, SAP and dozens of others. We ensure that you get a seamless experience as well as better performance and functionality from a highly tuned solution.

Migration Methods

There are many methods to migrate data, each method having different levels of cost and risk with varying advantages and disadvantages. It is important to identify which methods are optimal for your environment. To assist in the selection of the best methods, Table 1 describes and identifies the advantages and disadvantages of some of the basic data migration methods.
### TABLE 1. DATA MIGRATION OPTIONS

<table>
<thead>
<tr>
<th>Migration Method</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape Migration</td>
<td>Use a backup copy of data from the old systems and restore the backup to the new systems. The associated storage systems and/or servers must be offline to ensure that no new data is added.</td>
<td>Can restore to a different host; very compatible to all operating systems. Generally lower-cost solution; all organizations have backup software.</td>
<td>Major outage is required for the restore process and can be disruptive to or impact host performance at 2 separate times. Process is very slow and does not scale very well when large amounts of tapes are necessary.</td>
</tr>
<tr>
<td>IP-Based Host-Based Migration Using Replication Technology (not array-based replication)</td>
<td>Involves replication of storage volumes. Volume management is used primarily to control disk resources by mapping the logical view of storage space with the actual physical disks.</td>
<td>No impact on server performance. Method optimal if leveraging existing investment and for small amounts of data.</td>
<td>Significant investment is required. Method does not scale to large amounts of data. Software license fees could be required.</td>
</tr>
<tr>
<td>Host-Based Migration: Block (There are a number of tools: VMware, Veritas Logical Volume Management)</td>
<td>Host-based mirroring or replication solutions generally focus on file-by-file data movement to create a secondary data copy for disaster recovery purposes.</td>
<td>Initial setup and cost is low; for a few migrations involving a few hosts this technique works well.</td>
<td>Method affects server performance. It can become difficult to manage in heterogeneous operating system environments. Method becomes difficult as the amount and size of environment increases.</td>
</tr>
<tr>
<td>Host-Based Migration Using Server Virtualization (There are a number of tools: VMware, IBM® System Storage® SAN Volume Controller (SVC)]</td>
<td>VMware has created a tool set with VMotion to assist with server migrations that can assist with migrating the data as well. It is used for a storage area network (SAN) environment that is supported by VMware and when migrating a VMware virtualized environment.</td>
<td>VMotion solution is very good for small source and target VMware environments.</td>
<td>Server and SAN must support specific software. Performance impact on host; does not support boot devices and remote migration. Not fit for changing or consolidating operating systems. Focused only on x86 servers; currently only 33% of x86 servers run VMware and are compatible.</td>
</tr>
</tbody>
</table>
### TABLE 1. DATA MIGRATION OPTIONS (CONTINUED)

<table>
<thead>
<tr>
<th>Migration Method</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| **Host-Based Migration:** File Copy and NAS  
(There are a number of tools: Hitachi NAS Platform, using ScriptLogic Secure Copy, Hitachi Dynamic Replicator software, Rocket Arkivio Autostore and Microsoft® Robocopy) | There are a number of unique methods for specific host-based migrations that leverage NAS technology for file-based migrations either through NFS or through CIFS. To migrate CIFS or NFS file systems to or from an existing production file server NAS system to another, files are moved based on the network or file system protocols. | Useful in moving from one operating system to another or from one NAS platform to another platform; for example: NetApp to Hitachi NAS Platform.  
Leveraging existing namespace enables transparent data migration and simplifies administration of target environment. | Method is dependent on network, application and security infrastructure (authentication and permissions). |
| **File System-Based Data Replication**  
(There are a number of platform-specific tools: Hitachi Dynamic Replicator, NAS specific - Hitachi NAS Platform incremental data replication, NetApp SnapMirror and EMC Celerra Replicator) | Data replication allows copying or relocating of both file data and file system metadata, depending on the type of server operating system, replication software or NAS solution. Replication can also include not only the data but also the policy, rules and schedules for the file system environment. | Does not require 3rd-party tool.  
Automation and scheduling are built into product.  
Method is easy to use.  
If you can leverage existing namespace infrastructure, you can simplify configuration of target environment. | There is vendor lock-in.  
Homogeneous support for platform, not heterogeneous platform support. |
| **Appliance-Based Migration** | Method uses hardware or software technology focused on conducting data migrations. There are a few different types of appliance-based approaches, which vary, based on the technology involved. | Method minimizes downtime and can scale very well. | There is vendor lock-in. |

| IBM TotalStorage SAN Volume Controller virtualizes storage. | Storage area network (SAN) method uses a SAN switch, Cisco and Brocade. The SAN technology splits or mirrors the writes to both target storage systems until both are identical and stops writes to the source; then, the target storage environment is ready. | Method supports heterogeneous storage. | A highly scalable switch and large SAN are required, as well as a comprehensive suite of Cisco storage software.  
Both storage systems must be online throughout the migration.  
There is vendor lock-in. |

**Storage Virtualization Approach**

The use of heterogeneous storage virtualization technology to conduct a data migration minimizes risk and cost. Using the heterogeneous storage virtualization approach, the new storage system is connected to the SAN along with the old storage system. Then, the new storage system discovers the connected hosts and is properly configured and tested. The data is copied to the new environment and data is transparently redirected to the new storage system. No added outage is required. Once all the data is on the new storage system, the old storage system can be
decommissioned. This approach minimizes downtime and enables high data throughput. This approach is very flexible to allow for various outage windows and can scale to large amounts of data.

Table 2 provides a high-level comparison of 3 of the major data migration techniques. For an environment with 100MB/sec Ethernet and average server data size of 650GB, we have found the following comparisons.

For data migrations using host-based migration, the 2 outages for the host-based migration are for the discovery of the new storage system and the release of the old storage system after the migration has completed. These outages can vary depending on the operating system and the type of application. For example, old versions of Sun Solaris (Sun 5.8) would require a reboot after the data migration, resulting in an application outage. For subsequent versions of Sun (Sun 5.10 and later) the hosts releases the old storage system without an outage.

Table 2 illustrates that the nondisruptive migration service capability and storage virtualization approach has the least amount of impact on the environment. Based on some competitive methods, it requires a significant upfront investment in the storage virtualization technologies. If an organization is migrating to a virtualized storage environment, then this method has many significant pros with very limited cons. Because of Hitachi Data Systems software and platform technologies, along with our Migration Center of Excellence capabilities, our nondisruptive migration solutions are years ahead of competitors’ capabilities. And we address heterogeneous environments, while maintaining cost-competitive capabilities relative to traditional migration solutions.

<table>
<thead>
<tr>
<th></th>
<th>Nondisruptive Migration Capability</th>
<th>Storage Virtualization</th>
<th>Replication Technologies</th>
<th>Host-Based Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Platform</td>
<td>N</td>
<td>Y (any to any)</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Application Downtime/Server</td>
<td>None</td>
<td>&lt; 30 min</td>
<td>2 to 3 hours</td>
<td>2 hours (2 outages)</td>
</tr>
<tr>
<td>Number of Outages</td>
<td>None</td>
<td>1</td>
<td>2 (2nd outage is managed or scheduled)</td>
<td>2</td>
</tr>
<tr>
<td>Impact on Server Performance</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Clustered Hosts Support</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Technology Investment</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Cost of Migration Comparison

Based on the data that we obtained through the survey model, we developed a cost model to represent the overall costs of data migration. This section of the white paper focuses on providing our findings to empower you to adapt this research to your own environment. As described in the cost section, there are additional cost elements to data migration, which were not captured as part of this research due to limits of Web survey capabilities and sample size.
At the highest level, this research indicates that the industry average migration cost for Fibre Channel SAN storage is expensive. It costs more than the US$5,000/TB to US$7,000/TB commonly quoted by industry consultants, press or storage bloggers. Most of the posted or printed articles on this topic focused purely on the storage platform itself. They did not consider interoperability requirements that storage vendors impose on customers at the SAN switch, host operating system or host bus adapter level. Additionally, the technology and tool costs required to perform the migration itself are often excluded. And the effort required to rebuild the automation on the new storage platform with the use of scripts is often outside of consideration as well.

Figure 6 illustrates the different cost elements captured in this research.

Figure 6. Enterprise Storage Migration Effort and Costs per Terabytes Migrated

The overall average cost of enterprise storage migration easily exceeds US$15,000/TB. The following paragraphs provide detailed explanations for each category of migration cost.

The 1st element that must be clarified is the "per TB" metric used to express the migration cost. This metric is not based on storage capacity but on the size of the dataset migrated. This size is often estimated by considering the used allocated storage capacity. For the purpose of this paper, the migration cost model is assuming the data size or the used allocated storage capacity is the same.

For the purpose of adapting this cost model, organizations can translate this cost to a per host basis. The cost of an enterprise storage migration is directly proportionate to the number of hosts impacted. (Note that other factors also directly impact the migration cost, such as multisite implementations, and time and day of maintenance windows.) With the average capacity per host of 1.25TB to 1.5TB, the reported migration cost would range from US$10,000 to US$12,000 per host.

For the purpose of this research, the survey focused on both internal resources and external contractor spending used to perform the migration. Average cost of internal resources required was constructed from the respondents’ answers to 3 questions. Table 3 provides the summary of the results from the survey participants on the key criteria.

---

7 Source: Hitachi Data Systems/Tech Validate survey model
TABLE 3. KEY SURVEY CRITERIA

<table>
<thead>
<tr>
<th>Full Time Equivalent (FTE) Cost</th>
<th>US$126,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Migration Team</td>
<td>Average reported size of internal resource team was 6 individuals.</td>
</tr>
<tr>
<td>Average Team Loading Assigned on Migration Project</td>
<td>Average reported internal resource team loading was 45%.</td>
</tr>
<tr>
<td>Project Length</td>
<td>Average reported migration project length was 4 months.</td>
</tr>
<tr>
<td>Size of Data Migrated</td>
<td>Average of 1.25TB to 1.5TB of data per physical host (not virtual machine) was reported.</td>
</tr>
</tbody>
</table>

Using this data, we calculated the cost for internal resources was US$2,095/TB. For a detailed explanation of calculations, see Appendix D — Cost Analysis.

Migration technique is a key driver of the overall project cost and length. For internal resources, respondents reported host migration requires 4 to 6 times more effort compared to virtualization, as shown in Table 4.

TABLE 4. EFFORT REQUIRED FOR MIGRATION TECHNIQUES

<table>
<thead>
<tr>
<th>Data Migration Effort (US$) per TB — Internal Resource Only</th>
<th>Migration Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Host-Based Migration</td>
</tr>
<tr>
<td>Low</td>
<td>$1,767</td>
</tr>
<tr>
<td>High</td>
<td>$2,787</td>
</tr>
</tbody>
</table>

Enterprise organizations typically do not delegate host administration and maintenance to contractors for security reasons; therefore, the burden of the effort required for host migration falls mainly on the internal IT staff.

Similar findings were identified for host and virtualization migration technique impacts on project duration. Host migration projects were reported to be almost twice as lengthy as storage virtualization projects, as shown in Table 5. An important factor in increasing the duration of migrations is the scheduling of migration to avoid impact to the business. Nondisruptive migration eliminates the importance and impact of scheduling these maintenance windows. This can drastically reduce a few weeks or few months of migration efforts to a few days.
TABLE 5. MIGRATION PROJECT DURATION PER MIGRATION TECHNIQUE

<table>
<thead>
<tr>
<th>Migration Length</th>
<th>Migration Technique</th>
<th>Host-Based Migration</th>
<th>Storage Virtualization-Based Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td>13 weeks</td>
<td>7 weeks</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>19 weeks</td>
<td>11 weeks</td>
</tr>
</tbody>
</table>

Please see the Migration Approaches section of this document for more information on advantages and disadvantages of migration techniques.

The respondents reported an average of US$3,552/TB in service vendor cost. This value is computed from the service vendor spending divided by the average capacity migrated. The use of external contractors and consultants is a common practice in the industry to support off-business-hours migration. External consultants also help to reduce migration risk through experience and knowledge of migration technologies, tools and processes. The application operational requirements, migration techniques and tools, internal IT staff expertise and availability, maintenance windows and project size will greatly influence the number of contractors and consultants required. Average reported contractor and consultant personnel spending was US$251,000 per migration project. For the detailed survey results see Appendix C — Survey Results: Direct Costs.

The respondents reported an average of US$5,099/TB in migration tools and technologies spending. This value is computed from the reported migration tools and technologies spending divided by the average capacity migrated. The cost category is highly variable, based on the migration technique, vendor tools selected and licensing structure. See Appendix C — Survey Results: Direct Costs for the survey results regarding migration tools and technologies costs.

The 4th category of cost labeled "Indirect Infrastructure Cost" was modeled at US$263/TB. This indirect cost is defined as the excess infrastructure required while performing the migration and its associated costs. While performing the migration, target storage platform capacity must be equal to or greater than the capacity of the source storage system. The same logic extends to port requirements, power, cooling and so forth. To calculate the US$236/TB, we used industry-standard disk price per gigabyte and estimated cost of infrastructure over required time frame. Replace this cost with the appropriate estimate that better reflects your financial liabilities associated with keeping the source storage frames for an extended period while performing the migration. For detailed explanation of calculations, see Appendix D — Cost Analysis.

Respondents reported the 5th category of cost labeled "Effort Scripting" as an average of US$1,767/TB. This value is computed from the reported scripting effort in relation to the migration effort divided by the average capacity migrated. The migration effort baseline for this value was the sum of the internal resource effort and service vendor spending. There was high variability in the responses to this question, which could be due to the number of different platforms used by survey participants. Another interesting analysis from the survey respondents was that an average of 31% of the migration effort was reported to create new scripts on the target storage system(s).

Respondents reported an average of US$4,965/TB in host remediation effort with an average remediation effort of 4 days to support the most recent storage migration. This value is computed from effort reported multiplied by the
FTE cost divided by the average capacity migrated. The 4 main drivers were identified to explain the wide range of answers reported:

■ Length of maintenance windows due to application outage required.
■ The age of the respondents’ hosts and version of the operating systems running on these hosts.
■ Storage vendors’ interoperability requirements exclude older operating systems, host bus adapters and Fibre Channel SAN switches; an organization that did not keep their IT environment up to date may have to upgrade several hosts to support the target storage platform or platforms.
■ Storage vendor interoperability.

Lower Risk With Experience and Methodology Based on New Technologies

In our survey of customers’ experiences with data migrations, we have identified a number of critical factors that are essential to ensure successful data migrations. These critical success factors fall into the categories of experience and a number of best practices.

Organizations that reported having greater than 10% budget or schedule overrun, unanimously identified lack of experience as their biggest reason for not meeting budget and schedule (see Appendix E — Survey Results: Best Practices from Successful Data Migrations). When conducting migrations, leverage a team that has extensive experience with different types of migrations and methods. Look at companies like Hitachi Data Systems, with our industry-leading Migration Center of Excellence program, which has conducted thousands of data migrations; typical consultants have an average of 15 years of industry experience and more than 50 migrations completed. For more information on Hitachi Data Systems migration capabilities, see Appendix F — Hitachi Data Systems Data Migration Methodology.

Many of the best practices Hitachi Data Systems consultants have learned through years of experience are practices similar to those of organizations from the survey. Those who were successful identified the following key data migration best practices:

■ Logical grouping of applications.
■ Splitting migration into multiple phases.
■ Staging or testing.

NEW TECHNOLOGIES

While new technologies arrive often, and old technologies are constantly improved, the importance of migrating data nondisruptively remains of critical importance. Future enhancements such as customer self-service migrations will make things easier for organizations to enable data movement. However, since about 80% of any migration is planning, it is essential to strategize and plan with experts, such as HDS Global Services, to properly design a migration solution.
Best Practices and Lessons Learned From Successful Data Migrations

Hitachi Data Systems has leveraged this methodology to the benefit of many of our customers. A few of these successes are described below. For each customer success, we have described the situation, solution and key migration challenges that Hitachi Data Systems addressed. As shown in Table 6, Hitachi Data Systems has experience with many kinds of environments and very complex requirements.

TABLE 6. HITACHI DATA SYSTEMS DATA MIGRATION SUCCESS STORIES

"The critical factors in our decision-making process were 24/7 uptime and no interruptions to service during migrations. We had confidence in the migration strategy Hitachi developed and in their ability to deliver on time without interruptions."

David Hyland, Head Infrastructure Development and Implementation, Global Information Systems, Toll Group (Australia)

CHALLENGES
- Data growth predictions through organic expansion and acquisitions, and new business intelligence apps.
- Needed a solution to support a capacity and performance increase over coming 5 years of growth.

HDS SOLUTION
- Non-disruptively migrate to Hitachi Virtual Storage Platform (VSP) and Hitachi NAS Platform (HNAS) solution.
- Deploy Hitachi Command Suite (HCS), which includes Hitachi Dynamic Tiering (HDT).
- Ensure ease of migration and 24/7 uptime, run future apps.

RESULTS
- The change was cost neutral, but customer achieved significant performance, scale and reliability improvements over previous systems.
- Reduced backup from 12 to 4 hours thanks to performance improvements.

"The due diligence, the service and the knowledge provided by the Hitachi team surpassed any we’ve ever encountered in the industry. From conducting on-site analysis of existing infrastructure and understanding our unique needs, to managing the configuration, migration and build-out, all the services staff we’ve engaged throughout this effort have been outstanding."

Mark Holt, Sr. Director, Distributed Technologies, TSYS (Global Headquarters, USA)

CHALLENGES
- Support 35% yearly data growth.
- Maintain PCI compliance.
- Consolidate physical footprint via virtualization.
- Manage data growth; improve availability, performance, reliability and scalability.

HDS SOLUTION
- Migrate and consolidate to VSP.
- Migrate and consolidate 150 physical servers to 30 VMware servers.
- Hitachi Dynamic Provisioning (HDP), Hitachi Universal Replicator, HCS.

RESULTS
- Moved 40TB of data, without impact to client base, in a very short time.
- Enabled significant performance improvements for application workload.
- Eliminated colocation cost with flexible recovery solution.

"Everyone involved in the project worked together with great success. Our requirements were fully met, with a seamless migration that was, above all, interruption-free."

Caja Steinsmetz, IT System Administrator, Bundesamt für Gutverkehr (BfV) (Germany)

CHALLENGES
- Support data growth with 3-5 year operational sustainability, and meet flexiblility and low-risk requirements.
- Consolidate storage.
- Maintain availability, reliability, scalability and performance.

HDS SOLUTION
- Migrate to VSP and HNAS.
- Migrate and integrate storage with VMware.
- HCS, HDT, HDP and Hitachi TrueCopy.

RESULTS
- Pooled data into SAN and NAS for dynamic data flow and flexible service.
- Automated performance optimization for Oracle while reducing costs.
- Reduced space, heat and electricity needs; Savings = 52%.
<table>
<thead>
<tr>
<th>CHALLENGES</th>
<th>HDS SOLUTION</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required high availability and high computing capacity.</td>
<td>Migrate and consolidate to VSP.</td>
<td>Avoided downtime and business disruption.</td>
</tr>
<tr>
<td>Needed to coordinate migration to the new platform while ensuring required business continuity.</td>
<td>Deploy HDT to maximize performance.</td>
<td>Enabled faster back-end data access.</td>
</tr>
<tr>
<td></td>
<td>Employ system designed for scalability and growth capacity.</td>
<td>Saved energy. Less space used, less cooling needed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enabled unified management for all virtualized storage.</td>
</tr>
</tbody>
</table>

“Being able to perform all the operations while the system is live, a typical feature of the VSP enterprise solution from Hitachi Data Systems, has allowed us to avoid any downtime or disrupted service throughout the migration process. The excellent system implementation was made possible not only by Hitachi Virtual Storage Platform features, but also mainly, by the continuous dialog and the integration of various highly qualified professionals.”

Mauro Caracciolo, IT Infrastructure Manager, Publiescqua (Italy)

---

<table>
<thead>
<tr>
<th>CHALLENGES</th>
<th>HDS SOLUTION</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited storage required cumbersome process. Back up data, destroy the LUN, recreate the LUN, and then add it back to server.</td>
<td>Migrate 165 servers: 1/3 VMware servers.</td>
<td>On initial 50TB, return on investment paid for itself in a year.</td>
</tr>
<tr>
<td>Reduce footprint while providing app-consistency.</td>
<td>HDP: Hitachi Replication Manager. Hitachi Dynamic Link Manager and Hitachi In-System Replication bundle.</td>
<td>Improved performance, reliability and availability.</td>
</tr>
<tr>
<td>Improve availability, reliability and performance.</td>
<td>Agile solution for Microsoft® VDI.</td>
<td>Reduced footprint and data by terabytes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated dynamic provisioning versus manual.</td>
</tr>
</tbody>
</table>

“We were able to cut migration time by 1/3 using Hitachi services. We’ve used services from other vendors before, but the team from Hitachi was the most professional. From the project manager to the engineers, everyone was exceedingly focused and well-versed in the technology, helping the project go smoothly and finish on time. Only Hitachi Data Systems met all of Saint Elizabeth’s criteria. The technology was there, the versatility and resilience were there, and Hitachi offers an extensive yet focused services complement.”

David Bumey, Leader of IT, Saint Elizabeth (Canada)

---

<table>
<thead>
<tr>
<th>CHALLENGES</th>
<th>HDS SOLUTION</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate storage virtualization to consolidate and allocate resources.</td>
<td>Migrate from AMS to VSP and HNAS.</td>
<td>Automated resource allocation in hours versus days needed for manual allocation.</td>
</tr>
<tr>
<td>Manage storage.</td>
<td>Migrate VMware virtual machine environment.</td>
<td>Controlled management; gained full control of storage resources.</td>
</tr>
<tr>
<td>Plan and provide for data growth; maintain availability; reliability, scalability and performance.</td>
<td>Hitachi Device Manager, Hitachi Tuning Manager, Hitachi Tiered Storage Manager, HDT and HDP.</td>
<td>Reduced power and cooling reduction and cost savings.</td>
</tr>
</tbody>
</table>

“The in-depth involvement of Hitachi Data Systems Global Solution Services representatives from the outset meant that they had a great feeling for the complexity of our environment and really understood our challenges and requirements. Their expertise made the migration process seamless. All importantly, it minimized downtime for our clients.”

Corie Carter, Technical Architect, Kroll Ontrack (USA)
Conclusion: Develop Comprehensive Strategy to Reduce Both Cost and Risk

Data migration is an ongoing activity at all enterprise IT data centers. Traditional data migration projects consume considerable resources, are costly and involve considerable risk. Organizations can use key best practices and technologies to lower cost and risk of data migrations. Information contained in this paper describes costs of enterprise data migration and cost model for IT management to evaluate different data migration options. Based on this research and industry data, IT management can evaluate virtualization-based storage platform vendors, in conjunction with nondisruptive migration solutions and vendors that have vast migrations expertise. The results will guide IT toward lowering the organization’s data center operating expenses.

The Migration Center of Excellence, cost modeling data and experience Hitachi Data Systems has with data migrations point to solid solutions. We can help organizations reduce risk and costs for their data migrations now and for the future. Hitachi provides innovative storage architectures with market-leading storage virtualization capabilities and heterogeneous vendor support. We combine these architectures with Hitachi Data Systems experience and best practices to help organizations achieve lower costs and less risk for data migrations. Hitachi Data Systems Global Solution Services (GSS) organization has highly trained, knowledgeable and experienced data migration consultants who have migrated thousands of enterprise systems for our customers. Over the years, GSS has developed heterogeneous storage migration consulting expertise, as well as methodology and best practices that reduce migration risk.

When planning your next data migration, consider leveraging Hitachi Data Systems experience, knowledge and best practices to help you conduct your data migration cost-effectively with low risk. By reducing risk and costs for data migrations, you will reduce operating costs due to data migrations and more easily prevent technological obsolescence. This allows you to be more adaptive to change, leveraging existing investments by repurposing existing assets or facilitating technology refreshes to reduce costs.
Appendix A — Survey Demographics

The Hitachi Data Systems research goal was to raise market awareness on the topic of enterprise Fibre Channel SAN storage migration. The research also provided ways by which IT executives could tailor the findings of this research for their own environments. It used TechValidate Web surveys as the primary data collection outreach. The scope of this research was reduced to accommodate respondents' knowledge gaps and the limited time storage professionals can spend answering questions. With this in mind, we excluded several related and soft costs of storage migration from this project to ensure the survey would stay within these limits. The following 6 figures provide graphic views of survey demographics.

Appendix A — Figure 1 compiles responses regarding the number of source frames involved in the migration project. Enterprise frames are defined as those similar to EMC, Hitachi, HP and IBM systems usually available in a configuration greater than 2 controllers. Midrange or entry-level frames include other storage systems that are usually available in a 1- or 2-controller configuration.

Appendix A — Figure 1. Category of Storage Frame Migrated

Appendix A — Figure 2 compiles responses indicating the amount of data that was migrated from the source storage systems to the target storage systems in respondents' migration projects, indicating utilized storage capacity.
Appendix A — Figure 2. Respondents' Most Completed Fibre Channel SAN Storage Migration Project

Appendix A — Figure 3 surveys the number of respondents returning surveys from various industries.

Appendix A — Figure 3. Respondents by Industry Organization
Appendix A — Figure 4 presents the number of hosts the respondents used in their migration projects.

Appendix A — Figure 4. Number of Hosts Impacted by Migration
Appendix B — Calculation of Data Migration

Appendix B — Figures 1 through 4 summarize the data collected on internal resources used to support the most recent enterprise Fibre Channel SAN storage migration of the respondent.

The respondents’ fully loaded cost or the annual cost for a full-time equivalent (FTE) IT storage employee is represented in US dollars in Appendix B — Figure 1.

Appendix B — Figure 1. FTE Cost

Appendix B — Figure 2 depicts the number of internal staff allocated to respondents’ migrations.

Appendix B — Figure 2. Migration Team Size
Appendix B — Figure 3 presents the average amount of time each of the respondents’ assigned resources spent on this project.

Appendix B — Figure 3. Team Loading

Appendix B — Figure 4 illustrates the time frames of respondents’ projects.

Appendix B — Figure 4. Migration Project Length
Appendix C — Survey Results: Direct Costs

Appendix C — Figures 1 through 4 illustrate the direct costs respondents incurred as a result of their data migration projects. Appendix C — Figure 1 depicts the amounts respondents spent on service vendor personnel in US dollars during their migration projects.

Appendix C — Figure 1. Service Vendor Personnel Costs

Appendix C — Figure 2 reveals the amount of time respondents spent creating new scripts to duplicate the source of storage system administrative tasks (for example, backup, in-system replication, remote replication and so forth).

Appendix C — Figure 2. Effort Scripting
Appendix C — Figure 3 depicts the average amount of time and effort spent on each respondent’s affected hosts on remediation tasks, such as host replacement, operating system, patches, driver installation, host bus adapter replacement and so forth. This measurement excludes discovery phase, review and design, implementation and testing phase efforts.

Appendix C — Figure 3. Server Remediation Effort

Appendix C — Figure 4 illustrates the respondents' total costs for tools to support their migration projects (host migration software, discovery software, replication appliances and so forth).

Appendix C — Figure 4. Migration Tools and Technologies
Appendix D — Cost Analysis

Internal Labor Cost - US$2095/TB

"((FTE value * team size * team loading/100 * project length * 13/12)/48 weeks of work per year)/average size of data migrated"

The 13/12 multiplier is a normalization factor to compensate for the project length dimension, which was coded as 1 month equals 4 weeks in the survey database. The use of 48 working weeks per year default value is using 2 weeks of vacation time and 10 days of official holidays. This is representative of United States labor practices. No overtime pay factor was applied to this cost due to lack of knowledge on respondent organizations' labor practices, even if most storage migrations are executed outside normal business hours due to application downtime requirement. The direct internal resources cost will vary greatly based on actual location of the organization, labor pay practices and size of project.

Indirect Costs Calculation: US$236/TB

The limited number of survey questions prevented the research team from capturing the specific case of hard and soft costs. Hitachi Data Systems field delivery consultants provided several examples on this topic: The customer had to purchase additional Fibre Channel switches to extend the leasing agreement or pay additional maintenance fee on source storage systems to accommodate migration project length. Understanding that the source systems may have been purchased 3 to 5 years ago, it is challenging to approximate street price at the original time of acquisition to derive additional leasing or maintenance fees. The research team chose instead to use average street price estimates for modular and enterprise storage platforms to compute the excess monthly capacity costs, excluding extra Fibre Channel switches, ports and soft costs like power and cooling. The excess capacity acquisition value was estimated using a modular bit price of US$2/GB and an enterprise storage bit price of US$7/GB; these figures include hardware, software and maintenance. The reported size of data migrated was prorated over the reported number of modular and enterprise source frame(s) to estimate its acquisition value. The estimated acquisition value was then multiplied by a monthly cost factor of US$3 per US$100 of capacity value and the project length (expressed in months). It is similar to computing a monthly lease payment for the migrated capacity using average street pricing. Due to aggressive storage bit price erosion in excess of 30% per year, it is the belief of the research team that we are underestimating this cost by a wide margin.
Appendix E — Survey Results: Best Practices From Successful Data Migrations

Respondents who have successfully completed data migration within 10% of budget identified these results.

Appendix E — Figure 1. Successes With Minimal Budget Overruns

[Diagram showing data migration budget overrun and key reasons for success]
Appendix F — Hitachi Data Systems Data Migration Methodology

These migrations on average involve 40 servers and 10TB, with the largest data migration projects handling over 5,000 servers and more than 2PB. We can perform data migrations using all forms of technologies and methods described earlier in this paper: nondisruptive, host-based, replication, virtualized and using appliances. Our methodology, shown below, has been proven and tested, can be used for file and block-based migrations, and is flexible to accommodate multiple migration technologies and methods. Also, the Hitachi Data Systems migration consulting practice is not focused only on Hitachi storage systems; we leverage many 3rd-party products and know how to migrate to and from other storage vendors’ products. IDC’s Migration Services Overview\(^8\) notes that we are seen as a leader in heterogeneous migrations.

Our Migration Center of Excellence methodology starts with developing a comprehensive project plan with the organization before the actual data migration. The Hitachi Data Systems migration methodology leverages the best technique or approach based on the organization’s requirements and existing or planned new infrastructure. Hardware-based solutions from 3rd-party providers are sometimes utilized, depending on previous licenses or upcoming license purchases. Hitachi Data Systems methodology includes the key best practices that were identified in the survey in addition to the following:

- **Implementation**, through Hitachi virtualization technology, since 2004.
- **Discovery**, leveraging Hitachi tools.
- **Minimized disruption**, no changes made to applications or data, LUN configuration, and so forth, on external storage (other than LUN masking).
- **Improved commitment**, through mandatory stakeholder meeting.
- **Improved change control**, Change Advisory Board (CAB) migration events reviewed through our internal CAB for approval.
- **Audit trail**, migration workbook provides extensive documentation.

Appendix F — Figure 1. Phases and Activities of Hitachi Data Systems Data Migration Methodology

---

\(^8\) Source: Storage and Data Migration Services Overview, IDC, 2013