Performance

How to complete a successful cloud migration program

Mikhail Gloukhovtsev
Senior Cloud Solutions Architect,
Orange Business Services

orange™ Business Services

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1. Introduction

Once customers have defined their cloud strategy, one of the first questions they ask is, "How can I best move my application workloads to the cloud?" This involves various transformations – business, organizational and architectural. Enterprises need to know how much effort is required, how to ensure the continuity of IT services to the business and what changes in the application architecture are needed.

Enterprises need to source the right cloud model – Software as a Service (SaaS), Platform as a Service (PaaS) or Infrastructure as a Service (IaaS) – and how it is delivered – private, public or hybrid – for each application workload. This is based on:

- Financial considerations: What is the total the cost of ownership of the end-to-end cloud service and data lifecycle? Think about the choice, suitability and granularity of different charging models
- Functional and service level requirements: What features and services are required? What volume of traffic do you expect? What type of service level agreements and objectives (SLAs/SLOs) are important to you?
- Data security and privacy regulatory compliance: Can you protect your customer and employee data and comply with regulatory requirements? What about your intellectual property? How valuable is it? And how can effective protection be achieved?

Various levels of application data flow redesign may be required.

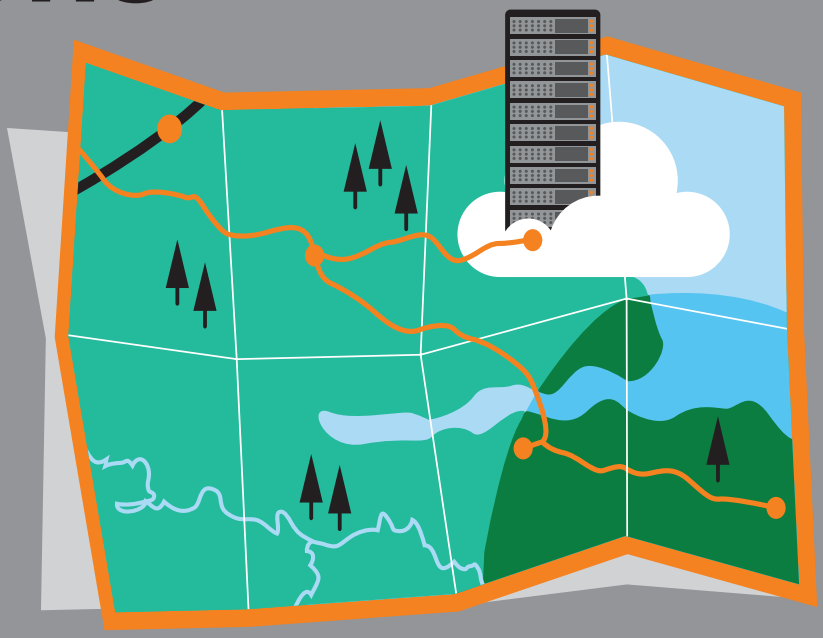
The next step is to define the methodology for application and data migrations – the focus of this paper. We will consider:

- Moving data to/from the cloud (the initial migration to the cloud and data recovery in case of service termination)
- Migrating data between different cloud environments, which is increasingly required to support new digital business models

We'll also briefly cover application data portability.

By defining a cloud migration plan, enterprises can de-risk cloud migration programs and accelerate their digital transformation program to ensure they remain relevant to customers' changing needs and expectations.

2. Application migrations to the cloud

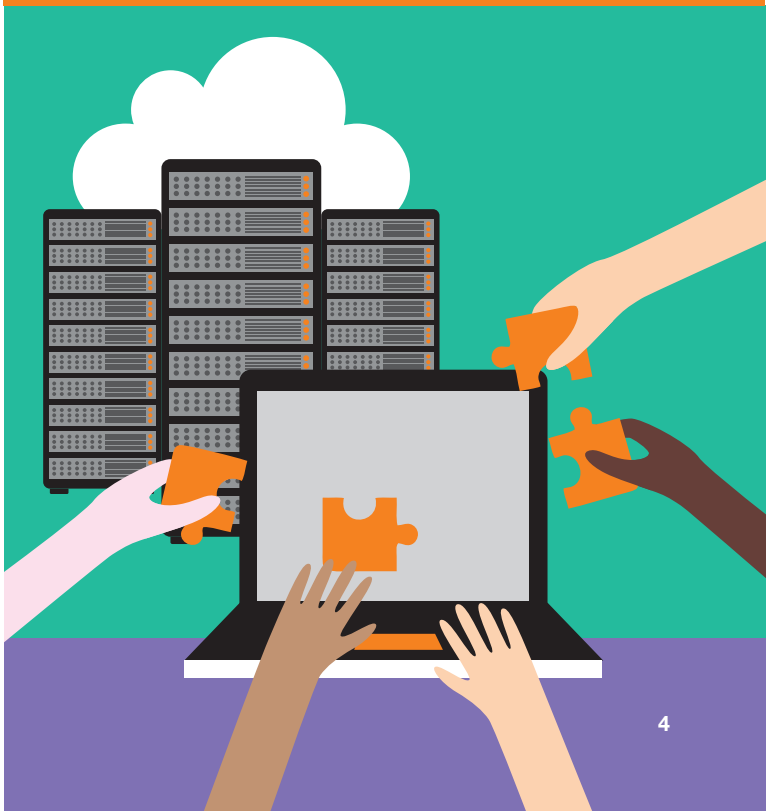


2.1 Factors determining cloud migration strategy

A cloud migration strategy depends on many factors, including:

1. Cloud service type – SaaS, PaaS or IaaS (Software as a Service, Platform as a Service, Infrastructure as a Service)
2. Cloud deployment type – private, public or hybrid
3. Application architecture – single- or multi-tier, usage pattern, application interdependency
4. Application criticality – acceptable downtime window
5. Amount of the data to be migrated
6. Data security requirements
7. Whether physical-to-virtual (P2V) server conversion is part of the migration to cloud

In some cases, a complete application redesign may be required. Alternatively, enterprises can migrate some application components to the cloud, keep legacy parts in the datacenter and then move it into private cloud at a later date.



What makes a migration to the cloud a success?

IT service delivery to the business units is critical:

- Low cost for the migration
- Online migration or a short downtime window
- Minimal impact on existing IT services
- Opportunity for P2V (physical-to-virtual) conversion
- Data security during the migration process

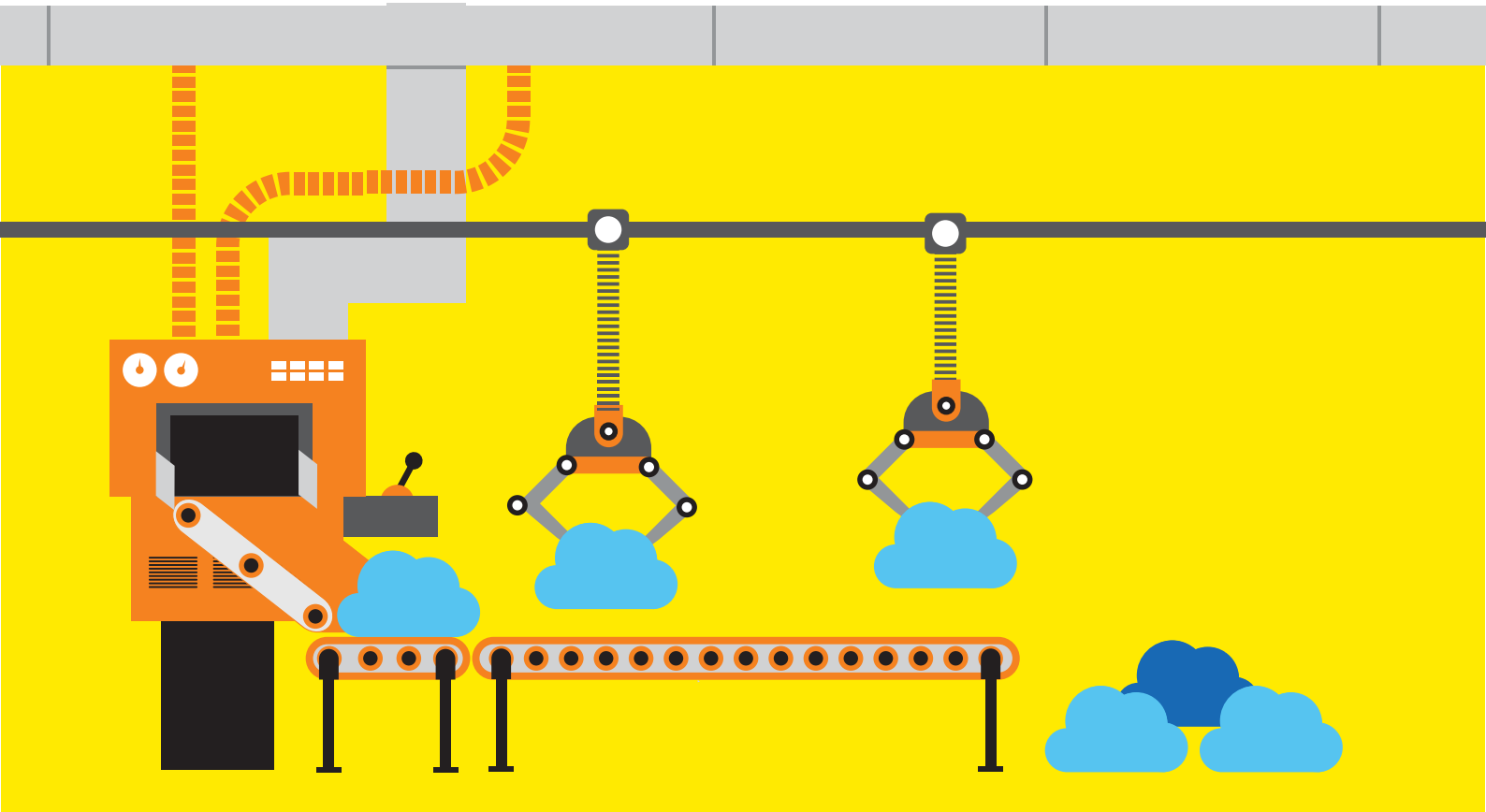
Many challenges need to be addressed:

- Significant downtime can be required to migrate critical applications
- Procurement of migration software tools and hardware and additional network bandwidth for the migration may be required
- Configuration changes are often needed to meet cloud IT standards
- Cutover planning: Can you afford to keep your existing environment up and synchronize the data with the new cloud-based environment until the new environment is tested and validated so that you can redirect all the traffic to it?
- Is a staging environment needed to reconfigure and validate the migrated applications and/or virtual machines before moving them into the production environment?

Application move groups – bundling applications and the associated server and storage infrastructure – should be identified to enable optimal sequencing. The plan is then defined in detail assessing the:

- Application migration strategy tier
- Data in-flight encryption requirements
- Migration downtime
- Downtime risk range
- Critical dependencies
- Server and data migration schedules
- Data synchronization solutions

Enterprises should set up a “migration factory” to develop the application and/or environment migration plan. All stakeholders need to agree on the migration success criteria and establish processes and governance to move legacy infrastructure to the cloud.



2.1.1 Cloud service type and the migration strategy

Gartner[1] suggests five methodologies for legacy systems' migrations to the cloud:

1. Rehost on Infrastructure as a Service (IaaS)
2. Refactor for Platform as a Service (PaaS)
3. Revise for IaaS or PaaS
4. Rebuild on PaaS
5. Replace with Software as a Service (SaaS)

Others categorize the migration based on the target cloud – IaaS, PaaS, or SaaS[2-5].

Software as a Service

Existing application data may need to be imported into the new SaaS platform and data formats converted. If only some application functionality is outsourced to the cloud, the business process should be revised to integrate the cloud and traditional services.

Platform as a Service

Migrating business applications based on standard application platforms, such as JavaEE or .NET platforms, is best achieved with a PaaS model. The application owner keeps control over the applications and the service provider supplies the application development and deployment environment. If the selected PaaS doesn't support some application features, it may need to be refactored or rebuilt on PaaS as outlined by Gartner above[1].

A relational or non-relational (aka NoSQL) database stores the existing application data with the related storage platform. The data will need to be exported and imported using a format required by the PaaS database.

Infrastructure as a Service

The goal is for the application to be deployed on the cloud service provider's servers. IaaS is the best choice for moving applications to the cloud when there is no time to re-engineer the applications. Compatibility of the server operating system (OS) and hardware features used by the existing applications should be reviewed, and application porting may be needed. For example, some legacy CPU features may be important for a given application.

Data migration to IaaS may involve data format conversions between different storage platforms; for example, moving block-data to object-based storage. Depending on the application criticality and data volumes, migrations can be done with the application online or offline with initial data copy and with delta synchronization later (the pre-copy process). If the data volume is large, a "swing storage system" can be used to copy data at the current datacenter, ship the storage system to the cloud datacenter and synchronize the delta.

2.1.2 Cloud service deployment model (public, private, hybrid) and the migration strategy

There are a few key considerations to decide which cloud deployment model to use:

- **Minimize costs**
  A public cloud is ideally suited to standardized, itinerant or highly variable demand-based applications. It's a good choice when you need to add incremental capacity during peak times and incur low upfront costs.
- **Data privacy, security and regulatory compliance**
  A private cloud provides more specific security controls and can be customized to an enterprise's policies, operational procedures and regional needs. Most enterprises adopt a private cloud to meet data privacy or regulatory needs for a specific application. Having this resource on tap for future use cases is beneficial to the business to increase agility.

  After making this initial investment, IT teams need to maximize its utilization with other applications to realize its full benefits. A hybrid cloud provides the best of both worlds, allowing data processing in a public cloud and storage in a private cloud.

- **Data traffic volume**
  If an application generates a lot of traffic or data needs to be encrypted, the WAN bandwidth costs and performance risks of a public cloud are likely to be high. However, some public cloud providers offer low-network latency solutions at a higher cost that may be suitable for your needs.
- **Reversibility**
  The potential complexity and costs of retrieving your business data from any chosen cloud service provider needs to be considered. This is a point often overlooked at the time of planning migration to cloud. For some public cloud platforms these costs can be considerable.
- **Maintaining existing IT standards**
  If similar server, storage and/or data protection platforms are used in your legacy platform and the proposed cloud model, fewer application architecture and configuration changes will be required. A private cloud may be preferable to reduce migration risks.

2.1.3 Cloud migration types

Using the five general cloud migration methodologies (rehost, refactor, revise, rebuild or replace), the following migration types can be identified[5-7]:

Type I: Replace some application architectural components with cloud offerings

This is the least invasive type of migration, exemplified by SaaS and PaaS. It's important that the application vendor validates and supports the SaaS cloud platform you move your application to.

Type II: Migrate some application functionality to the cloud

One or more application layers, or a subset of architectural components from one or more layers implementing a particular functionality, are moved to the PaaS cloud.

Type IIIa: Migrate the whole application stack to the cloud

This migration type is used to move to an IaaS cloud. Virtual machine clones containing an encapsulated application can be imported to the cloud-based environment. Changes to the storage access, IP addresses, DNS, backup configurations will be required. This should be determined by testing.

Type IIIb: A green-field deployment with the application data imported into the cloud

Some cloud providers may not allow the use of the customer virtual machine images. An alternative is to install the application on an AWS or Azure virtual machine from scratch. The existing data should be copied across securely. While this may be seen as the most straightforward solution, it can be time consuming.

Type IV: "Cloudifying" the application by completely replacing the entire application with a composition of services running in the cloud (SaaS)

2.1.4 Network solutions for the cloud migration process

Enterprises need to consider the network bandwidth, application tolerance to network latency and security when moving the traffic to and from the cloud.

While the Internet is a simple, flexible and cost-effective way, key questions should be addressed:

- How long will it take to migrate data with your available bandwidth?
- Should additional bandwidth be provisioned only for the migration? Can it be purchased for a short period?
- How secure is the data traffic in transit?
- Is redundant connectivity needed to mitigate network reliability issues and complete the migration on time?

A secure virtual private network (VPN) is one way to secure data during the migration. It can operate over the Internet, providing high levels of security through encryption.

Do you need to purchase additional bandwidth?

Use of WAN optimization appliances is recommended to address network bandwidth issues during the migration process. Potential performance gains can be assessed using an emulator and application performance analysis tool[8].

For bandwidth-heavy applications that are sensitive to network latency, cloud providers offer dedicated network connections; for example AWS Direct Connect, Microsoft ExpressRoute or Google Cloud Interconnect.

Microsoft ExpressRoute can be used to establish connections to Microsoft Azure, Office 365 and CRM Online. Connectivity can be from any-to-any network (IP VPN), a point-to-point Ethernet network or a virtual cross-connection through a co-location facility. As traffic doesn't go over the public Internet, enterprises benefit from higher speeds, reliability and security with lower latency.

Google Cloud Interconnect presents Cloud Platform customers with several connectivity options to connect their network to Google. One of them is Carrier Interconnect, enabling enterprises to connect their network to a service provider with a direct connection to Google. This provides higher availability and security, and lower latency, since the traffic travels from the customer's datacenter to the interconnect service providers and direct to Google via network peering.

VMware vCloud Air offers Direct Connect – private, high-throughput, dedicated connectivity for connecting on-premises or co-located environment – which is routed over the public Internet[9].

Business VPN service providers enable enterprises to extend their on-premises environments into a choice of cloud providers. For example, Orange provides Business VPN Galerie that extends the corporate VPN to cloud providers, such as AWS, Azure and the Google Cloud Platform, via fully-secured gateways with end-to-end high performance and reliability. The traffic is not exposed to the Internet and therefore secured and performance SLAs apply[10, 11].

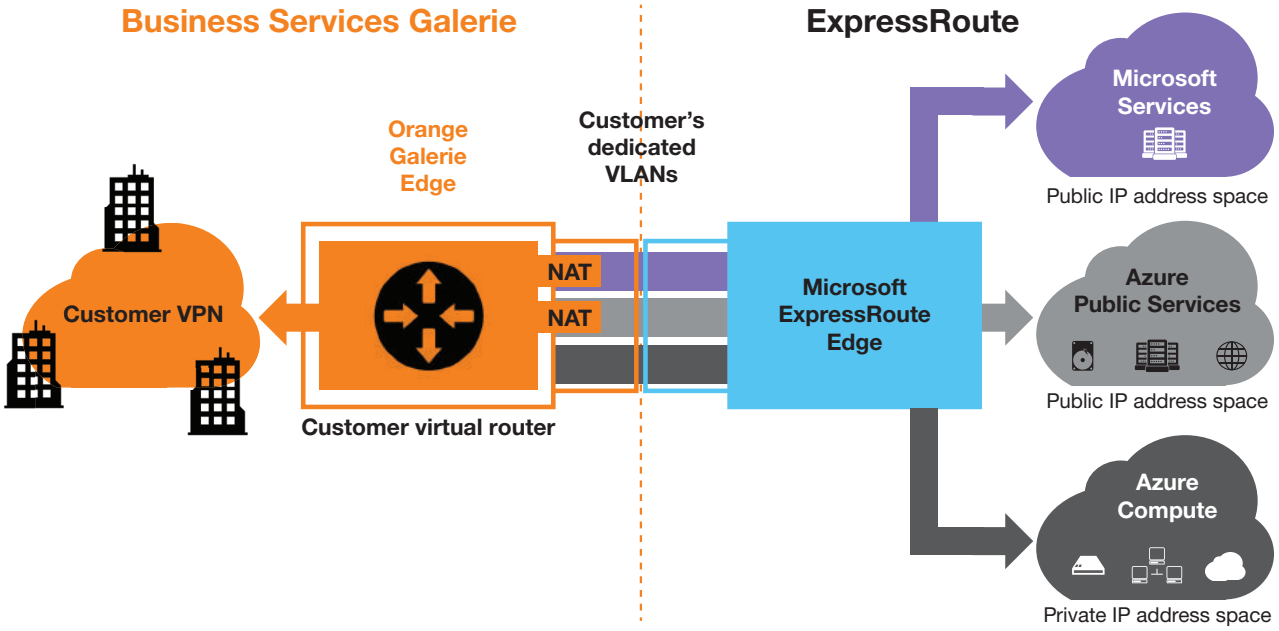


Figure 1: Business VPN Galerie connections to the services accessible via ExpressRoute

2.2 Migrating unstructured data to the cloud

There are several methods to migrate application data and virtual machines images encapsulating applications and their data:

- **Migrate a server image**
  Take the example of a server image that is a file containing a complete operating system (OS) and, in most cases, server management tools and middleware. As the guest OS and device drivers used in a cloud are unlikely to be an exact match to those in the legacy environment, the server will need to be reconfigured and new management tools used.

  Changes in the application configuration will be required, followed by data synchronization to reflect changes when the source instance is kept online during the migration.

  Server migration options include Physical-to-Virtual (P2V), Physical-to-Image (P2I) or Virtual-to-Virtual (V2V) conversions. P2V instantiates the image into a target hypervisor or cloud whereas P2I captures the image as a file and stores it on disk.

  You can create a virtual machine using the cloud image catalog, installing the application and copying the data from the source system. Alternatively, the application data can be restored from a cloud backup service with the OS and management tools configured. The new virtual machine's kernel, software packages and library versions may differ from those in the legacy environment and modifications to the application may be required.

- **Online virtual machine migration**
  Virtual machine cloning can be hot/online or cold/offline. Offline cloning takes less time and has greater chance of creating a consistent image.

  Several proprietary and OpenStack tools ease workloads migrations. They make a complete copy of the existing server software by capturing the contents of disks and, optionally, of server hardware by documenting the source hardware.

  If you keep your own licenses, consider whether the vendor provides any options for transferring the licenses to the cloud.

Cloud provider export/import services

Transferring large data volumes across the Internet can be cost and/or time prohibitive and cloud service providers' import/export services may be preferable.

2.3 Migrating structured data to the cloud

2.3.1 General considerations

Your choice of migration method depends upon the application/database tolerance for downtime, the size and complexity of the database and the bandwidth of the connection to the cloud.

Cloud export/import services offered by cloud service providers can be used to move large databases; for example, a 100TB Oracle database with 50GB of daily changes. A full database backup is done to a portable storage system or to a "swing" storage array. The encrypted data is sent to the cloud provider who restores the database from the full backup. Following that, the cloud database instance is synchronized with the source database using native database tools.

The choice of computer tier and cloud storage for the migration is also key. A higher pricing tier reduces the migration time for large databases – it means less application downtime and network usage charges. You can then revert to a lower pricing tier once the deployment is completed. If the cloud provider charges by the hour, a shorter migration time may offset the costs.

2.3.2 Migrate to a cloud-based database service or run databases on cloud virtual machines?

When moving databases to the cloud, there are two main options:

- A Platform as a Service (PaaS) database or a Database as a Service (DBaaS) that is optimized for Software as a Service (SaaS) application development
- Databases on a virtual machine: Also known as an Infrastructure as a Service (IaaS)

Your choice depends on your database compatibility and cost-efficiency.

After creating a virtual machine, the database installation process is the same as it is in an enterprise datacenter. As the range of Microsoft and Linux virtual operating systems supported by cloud providers is broader compared to the database service providers, this option is more flexible.

Running databases on the cloud-based virtual machines means the enterprise takes management responsibility for backups, availability, security and database patching, etc. In contrast, you get a lot of the features out-of-the-box from a cloud service provider.

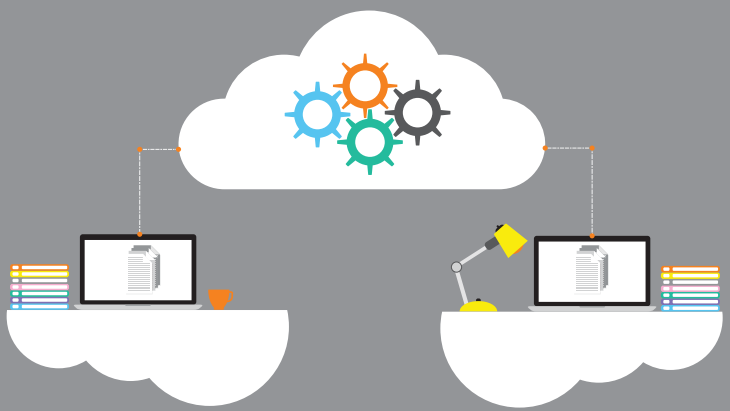
Usually cloud-based database services do not include the license cost explicitly as it is built into the monthly recurring charge. Whereas, if you install the database onto the cloud provider's virtual machines, you need to license the database for each virtual machine instance.

If you need to temporarily run your database on virtual machines, you may opt for a short-term license. While they are less expensive – a one-year term license can be purchased from Oracle for as little as 20 percent of the product list price – using cloud-provider database services may be more cost-effective. You may also be able to migrate your existing licenses to some cloud service providers.

A range of database migration wizards and migration services are available. The source database can be backed up to the cloud and then the data restored to the destination cloud database. Some cloud vendors encrypt the backup data at the source, in transit and at rest, and some do not.

3. Inter-cloud migration and workload portability

While private cloud dominated the early days of IT transformation, a multi-cloud approach is preferred by most enterprises today. Hybrid cloud empowers IT to be a broker of cloud services – providing the control and visibility that IT teams need, and the on-demand self-service capabilities that developers and application users expect.



The growing demand for hybrid cloud is driving the need for interoperability and openness across on-premises and public cloud environments.

The Open Data Center Alliance (ODCA)[12] considers the interoperability from two perspectives; interconnectability and portability:

- Interconnectability – the parallel process in which two coexisting environments communicate and interact
- Portability – the serial process of moving a system from one cloud environment to another

Let us take a brief look at both of them.

3.1 Cloud interconnectability

Equinix offers a broad choice of cloud service providers, such as VMware vCloud Air, AWS, Google Cloud Platform and Microsoft Azure, with direct connections to these cloud services via Equinix Cloud Exchange™, cross connects or Ethernet services.

Equinix Cloud Exchange™ provides virtualized, private direct connections that bypass the Internet to provide better security and performance with a range of bandwidth options. This enables companies to build hybrid cloud solutions meeting their business needs. Furthermore, cloud services providers can benefit from connectivity to Orange Business VPN Galerie service on the Equinix Cloud Exchange™.

3.2 Data and workload portability in the cloud

Data and workload portability requires the movement of virtual machines, application data and environment metadata between clouds. Environment metadata like account structures, user permissions, policies, load balancers is often cloud provider-specific.

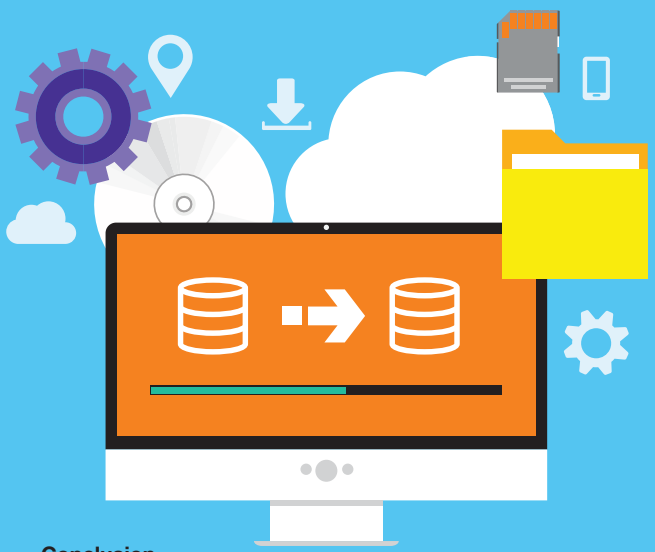
OASIS – the Topology and Orchestration Specification for Cloud Applications (TOSCA)[13] – aims to improve application portability and manageability by composing a service once and playing it on any cloud. It provides an orchestration development framework for the entire application lifecycle by modeling the topology and deploying it to your infrastructure of choice, while managing, monitoring, scaling and healing tasks.

There are promising developments in using containers (Docker, CoreOS, etc.) for migration between different clouds. This means programmers may not need to rewrite the code for each new operating system and cloud platform. Not all applications are “container-friendly” though and containers have security-related limitations. The container security and management of containerized applications in production environments are discussed in the recent paper, “Containers: IT management and operations aspects[14]. This means programmers may not need to rewrite the code for each new operating system and cloud platform. Not all applications are “container-friendly” though and containers have security-related limitations. The container security and management of containerized applications in production environments are discussed in the recent paper, “Containers: IT management and operations aspects[15].”

Another aspect of data portability is the integration and mobility of cloud- and on-premises storage. This portability can be achieved by using cloud storage arrays and gateways.

4. Conclusion

Migration to the cloud raises many questions. Selection of the best solution depends on the individual needs of each organization. By assessing your options carefully you can develop your cloud transformation programs and improve the overall effectiveness of your migration to cloud, creating flexible foundations to adopt new digital business models.



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