Enabling Hybrid Cloud Today with Microsoft Technologies

Overview Technical Article

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Abstract: With the ambient credo to “do more with less, with a better agility and time to market”, IT inevitably becomes a service provider for its enterprise and need to run like a business. The undertaking also requires a step further in the way the IT delivers its services to its customers: internal businesses and beyond. IT has indeed to deliver the services in an industrialized way for greater speed and lower cost. This requires increasing their overall core infrastructure operational maturity in two main areas.

The first one aims at improving the management of their own on-premises IT landscape and traditional services by evolving towards a private cloud, i.e. an optimized and more automated way to provision and operate (a catalog of) services for businesses. The second one consists in enhancing their service offerings by utilizing off-premises public cloud augmentations (for acceptable cases of use) as (lower-cost) add-ons to existing services in the catalog.

The combination and interaction of these two cloud paradigms results in the emergence of the hybrid cloud which meets the demands and the expectations of the business. Hybrid cloud spans the two above implementations. A service request can be instantiated in either implementation, or moved from one to another, or can horizontally grow between the two implementations (cloud bursting for instance).

This paper discusses how Microsoft can help your organization achieve a successful hybrid cloud strategy and present the enabling technologies from on-premises, cross-premises, and off-premises implementation of (parts of) the services. Several typical patterns and common scenarios are illustrated throughout this paper.

Table of Contents

[Introduction 1](#_Toc423352127)

[Objectives of this Paper 1](#_Toc423352128)

[Non-Objectives of the Paper 2](#_Toc423352129)

[Structure of this Paper 3](#_Toc423352130)

[Audience of this Paper 3](#_Toc423352131)

[Conventions in this Paper 3](#_Toc423352132)

[A Brief Introduction to the Cloud 5](#_Toc423352133)

[Cloud Computing 5](#_Toc423352134)

[Different Service Models 7](#_Toc423352135)

[Different Deployment Models 8](#_Toc423352136)

[The Cloud on Your Term: The Hybrid Cloud 11](#_Toc423352137)

[Opportunities and Challenges of the Public Cloud 11](#_Toc423352138)

[Business Reasons for Thinking Hybrid 13](#_Toc423352139)

[Towards An Hybrid IT 13](#_Toc423352140)

[Paradigms for Hybrid Cloud 16](#_Toc423352141)

[Use Case Scenarios for Hybrid Cloud 17](#_Toc423352142)

[Additional Considerations for Hybrid Cloud 24](#_Toc423352143)

[Microsoft Hybrid IT Approach 30](#_Toc423352144)

[Deployment Choice for the Cloud 31](#_Toc423352145)

[Commonalities Spanning Private and Public Clouds 34](#_Toc423352146)

[Symmetric Functionalities 45](#_Toc423352147)

[Hybrid Connectivity Technologies 55](#_Toc423352148)

[Enabling Common Hybrid Experiences 59](#_Toc423352149)

[Hybrid Datacenter 59](#_Toc423352150)

[Hybrid Cloud Storage 61](#_Toc423352151)

[Hybrid Line-Of-Business (LOB) Application 62](#_Toc423352152)

[Hybrid Office Collaboration with Office 365 67](#_Toc423352153)

[Hybrid Big Compute 68](#_Toc423352154)

[Hybrid Big Data (and Machine Learning) 71](#_Toc423352155)

[Conclusion 75](#_Toc423352156)

[References 77](#_Toc423352157)

# Introduction

## Objectives of this Paper

Economic dictates are shaking us. With:

* The global economic contraction to which every organization is faced with,
* The productivity imperative with the ambient credo to “do more with less, with a better agility and time to market”,
* Etc.

Every organization has no other choice left than becoming leaner, better focused, more fit-to-purpose, etc. In such a foreseeable situation, organizations need breakthrough changes in order to survive.

This comprises ALL systems of production and distribution - including IT - and the survivors will be the ones that specialize in what they do best and most efficiently. As far as IT is concerned, the economic benefits from combined cloud innovations with:

* The obvious: new ways of delivering and operating the IT infrastructure and systems;
* The profound: new business processes.

This implies to refactor and redistribute business in order to be done most efficiently. Consequently, IT will inevitably become a service provider for its own organization and will need to run like a business (if it’s not already specifically the case today). Running applications, databases, operating systems, etc. will be replaced by provisioning a complete solution as an IT service. As part as an evolution towards a service provider, IT will (ultimately) offer an IT services catalog.

The undertaking also requires a step further in the way the IT markets, manages, and delivers its services to its customers: internal business units and beyond. Considering the above, IT has indeed to deliver the services in an automated way for greater speed, lower cost and better agility.

As such, in this context, the cloud emerges as a major disruptive force in shaping the nature of business and plays a major opportunity and role. An increasing number of people recognize the benefits of locating IT services in the cloud to reduce infrastructure and ongoing datacenter operational costs, maximize availability, simplify management, take advantage of a predictable pricing model - provided that the resource consumption is also predictable, rapidly deliver to the market, elastically scale in respect to the demand, and open multichannel access for the business.

However, transition to the cloud is not going to happen overnight. Most organizations still have a lot of IT assets running in on-premises datacenters. These will eventually be migrated to the cloud, but a shift to the next paradigm always takes time. It’s all the more so that, for these IT assets, some components or features might not be located in the cloud, such as third-party services or sensitive data that must be maintained onsite under a specific control.

At the moment, for most organizations, we are in the middle of a transition between running everything on-premises and hosting everything in the cloud. Consequently, the transition requires for the organizations increasing their overall core infrastructure operational maturity in two main areas:

1. Improving the management of their own on-premises IT landscape and traditional systems (servers, storage devices, network components, and other hardware and software assets in the datacenter) by evolving towards a private cloud, i.e. an optimized and more automated way to provision and operate (parts of) (a catalog of) services for businesses, and as such that provides (consolidated) views of all management tools and consistent reporting across heterogeneous systems to adequately sustain not only IT operations but also IT chargeback capabilities.

Leveraging a capability maturity model for the datacenter management and virtualization greatly helps for such a journey in identifying the current (optimization) level for IT and defining the optimized path along with the core capabilities to enhance in order to build a more agile and manageable IT infrastructure.

1. Enhancing their service offerings by utilizing off-premises public cloud augmentations (for acceptable cases of use) as (lower-cost) add-ons to existing IT assets. Such a dynamic is actually twofold:
2. On one hand, this indeed supposes to substitute in-house on-premises systems for inexpensive public cloud services when they provide the same functionality.
3. On the other hand, it implies for IT to build its own systems as cloud services using other (ecosystem) cloud services as building blocks.

The combination and interaction of the two above areas and the related cloud approaches (private vs. public) results in the emergence of a hybrid cloud solution which meets both the demands and the expectations of the businesses. As mentioned above, “Hybrid” is a term that positions the IT investment somewhere along this continuum. Hybrid cloud spans the two above implementations.

A service request for a specific workload can be instantiated in either implementation, or moved from one to another, or can horizontally grow between the two implementations (cloud bursting for instance), etc.

This long-term transition leads to a situation where IT inevitably evolves over the time from a “hoster” of applications to a broker of IT-based services, whether they are traditional services, private cloud, public cloud, hybrid cloud, or some blend to some extent. The workloads evolve from traditional and/or private cloud deployments to hybrid to possibly public for some services as a whole.

Gartner calls this new model “hybrid IT” where IT becomes both a (Cloud) Service Provider and an internal Cloud Service Broker (CSB) for its business units. This is IT as a Service Broker (ITaaSB), which represents IT service as being delivered to the business in a manner that is both agile and cost-effective – i.e. in a “pay-as-you-go” (PAYG) fashion, while meeting the quality of service (QoS) or service level parameters, and the key performance indicators (KPI) that the businesses have come to expect today.

In such a context, this paper discusses both the benefits and the challenges presented by the hybrid cloud approaches, illustrates some key use case scenarios and business reasons, presents how Microsoft can help your organization achieve a successful hybrid cloud strategy and introduces the enabling technologies we provide for a successful hybrid implementation of IT-based services. The paper concludes with several typical illustrations based on Microsoft technologies.

## Non-Objectives of the Paper

This paper is intended as an overview document for hybrid cloud and how a related strategy can successfully be defined with both confidence and efficiency. Whilst introducing the enabling technologies Microsoft provides for a successful hybrid implementation of IT-based services, it doesn’t provide as such neither in-depth description nor detailed step-by-step instructions on how to implement a specific use case scenario. Where necessary, it instead refers to more detailed documents, articles, and blog posts that describe a specific feature or capability.

## Structure of this Paper

To cover the aforementioned objectives, this paper is organized by themes which are covered in the following sections:

* The section § A Brief Introduction to the Cloud constitutes a kind of primer to the Cloud, and such defines and describes the various types of clouds and their characteristics and benefits. It provides you with the context of the rest of this paper.
* The section § The Cloud on Your Term: The Hybrid Cloud discusses both the opportunities and challenges inheriting from the public cloud and explores in this context the hybrid cloud approach along with the business reasons sustaining it for IT. The hybrid IT organizational model and the new IT as a Service Broker (ITaaSB) is further discussed in terms of a transformation path for IT. Then the section continues with use case scenarios to illustrate typical IT services that can benefit from this perspective. Finally, the section includes additional technical and organizational considerations for the aforementioned scenarios.
* The section § Microsoft Hybrid IT Approach introduces the Microsoft value proposition for the hybrid approach and discusses the distinct advantages it offers to enable hybrid cloud today in your organization at your own pace. Specific (cloud) offerings, products and technologies are further examined.
* The section § Enabling Common Hybrid Experiences finally illustrates common hybrid experiences that can be smoothly and seamlessly enabled thanks to the previously introduced Microsoft’s (cloud) offerings, products and technologies.

## Audience of this Paper

This paper is intended for software designers, developers, system architects, and IT professionals that are interested in having an understanding of what benefits hybrid clouds can bring to them, how to address the unique set of challenges resulting from hybrid IT services that span the on-premises and the cloud divide, and to leverage the Microsoft offerings in this area.

## Conventions in this Paper

In this paper,

* **Windows** may be used as a generic term that includes the Windows Server operating system and the Microsoft Azure platform (formerly Microsoft Azure).
* When not detailed, the term **Cloud** relates to the public cloud by default, and private cloud deployments are included in the generic **“on-premises”** term.
* Windows Server 2012 R2 constitutes the reference version when referring to the **Windows Server** operating system.

**Note** For an high-level overview of Windows Server 2012 R2, see the free eBook [Introducing Windows Server 2012 R2](http://aka.ms/682788pdf)[[1]](#footnote-2).This eBook introduces the platform’s features and capabilities, with scenario-based advice on how the platform can meet the needs of your business.

**Important note** As of this writing,the next version of the Windows Server operating system, i.e. Windows Server 2016, is a prerelease software. The currently available [Windows Server 2016 Technical Preview 2](https://www.microsoft.com/en-us/evalcenter/evaluate-windows-server-technical-preview)[[2]](#footnote-3) is not intended for production environments, nor full evaluations, and will not be covered in this document. Nevertheless, nothing prevents you from starting investigating it. When this version will be generally available on the market, this document will be updated in accordance to reflect the key benefits in the context of hybrid cloud.

* System Center 2012 R2 constitutes the reference version when referring to the **System Center** management suite.

**Note** For an high-level overview of System Center 2012 R2, see the free eBook [Introducing Microsoft System Center 2012 R2](http://download.microsoft.com/download/C/8/A/C8A5F520-F31E-4BB4-B972-8D2525D17C38/Microsoft_Press_ebook_Introducing_System_Center_2012_PDF.pdf)[[3]](#footnote-4).This guide introduces core features and functionality, with technical advice and under-the-hood insights from members of the System Center team at Microsoft.

**Important note** The next version of the System Center suite, i.e. System Center 2016, is an early pre-release build as of this writing. Many of the features and scenarios are still in development. As such, the currently available [System Center 2016 Technical Preview 2](https://www.microsoft.com/en-us/evalcenter/evaluate-system-center-technical-preview)[[4]](#footnote-5) is not intended for production environments, labs, nor full evaluations.

System Center 2016 will deliver unified management across on-premises, service provider, and Microsoft Azure environments, thereby enabling the Microsoft Cloud OS platform. System Center 2016 will offer exciting new features and enhancements across infrastructure provisioning, infrastructure monitoring, application performance monitoring, automation, backup and IT service management. For a sneak peek of some of the innovation you’ll experience, see the blog post [Now Available - System Center 2016 Technical Preview 2](http://blogs.technet.com/b/systemcenter/archive/2015/05/06/now-available-system-center-2016-technical-preview-2.aspx)[[5]](#footnote-6). When this version will be generally available on the market, this document will be updated in accordance to reflect the key benefits in the context of hybrid cloud.

# A Brief Introduction to the Cloud

This section constitutes a kind of primer to the Cloud, and such defines and describes the various types of clouds and their characteristics and benefits. If you’re familiar with cloud terminology, you can skip this section and directly move to the section § The Cloud on Your Term: The Hybrid Cloud.

## Cloud Computing

**Cloud computing** represents one of the most notable evolution of IT both from an economic and technological perspectives.

Cloud computing refers to application and IT delivered as services in a private intranet or over the Internet and consumed by organizations in a “**pay-as-you-go**” (PAYG) fashion opposed to traditional computing (whereby computing resources are systematically fully-owned by organizations), or alternatively to outsourcing (whereby computing resources are rent for fixed predefined cost by organizations).

A cloud should be understood as a shared pool of physical and virtual computing resources - including servers, storage (devices), networks, middleware, applications, and services. Clouds consist of a series of capabilities, abstracted from the underlying hardware. These capabilities can be accessed across the public Internet or over a private intranet. Benefiting of scale effects and highly optimized and performing infrastructures and technologies, world-class cloud computing service providers can furnish to organizations the illusion of infinite computing resources available on demand as well as a flexible consumption model that can scale up and down dynamically according to the considered organization’s needs.

This said, cloud computing is still a relatively new discipline - one can have in mind the early work[[6]](#footnote-7) in 2009 of the UC Berkeley Reliable Adaptive Distributed Systems Laboratory, and as such, definitions (may) vary.

The National Institute of Standards and Technology (NIST) developed the following definition of cloud computing[[7]](#footnote-8) so that anyone can share a common understanding: “Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.”

According to the NIST, the five essential characteristics of cloud computing are:

* **On-demand self-service**. Cloud consumers can order or release resources in a self-service manner followed by an automatic allocation or revocation of those resources (that is, scale-up and scale-down with little or no human intervention).
* **Broad network access**. The network includes public clouds that are accessible over the Internet and private clouds that are accessible over an intranet. Both are accessed through standards that promote use by a variety of thick and thin clients such as workstations, laptops, tablets, and mobile phones.
* **Resource pooling**. Cloud consumers use resources such as storage, processing, memory, and network bandwidth that are maintained and managed by a service provider and shared with other consumers in multi-tenancy. A consumer only manages the resources received and not the underlying technologies, infrastructure, and operations.
* **Rapid elasticity**. The consumed service scales up and down dynamically based on demand. To the consumer, the service seems unlimited.
* **Measured service**. Cloud systems use a metering capability to monitor, control, and report use of resources to provide transparency for both the provider and consumer of the resources.[[8]](#footnote-9)

Additional characteristics of cloud computing include the following:

* **Abstraction**. Cloud computing involves a paradigm shift in which the difficult details of maintaining a computing infrastructure are abstracted from consumers and even largely from IT professionals, who no longer need to know about or control computing technology. Cloud computing is like consuming electricity from a utility instead of producing your own.
* **Commodity services**. Resources offered in the cloud are standardized commodity services.
* **Geo-distribution and redundancy**. Today’s clouds consist of large datacenters in locations all around the globe.
* **Virtualization**. Virtualization is the foundation of cloud computing. It provides the capability to pool computing resources from clusters of servers and to dynamically assign or reassign virtual resources to applications on demand.

Traditional outsourcing differs from cloud computing in the following ways:

* **Static price and duration**. In traditional outsourcing, the consumer pays a fixed price for a set duration to consume a service and the costs are the same even if the service is not consumed.
* **Static capabilities**. In traditional outsourcing, the consumer rents dedicated machines and instances of software. Scaling down typically involves paying penalties, and scaling up requires lead time to order, deliver, and install the new infrastructure.



Figure 1. More flexibility via agile scaling up or down in cloud computing compared to traditional outsourcing

## Different Service Models

A common way to define clouds is by the service model that they provide, or in other words, the type of service that they offer.

As of this writing, the following service models are defined by NIST:

* **Infrastructure as a Service (IaaS)**.
* **Platform as a Service (PaaS)**.
* **Software as a Service (SaaS)**.

One should note that, beyond these core service models, new ones emerge such as the Identity Management as a Service (IDaaS).

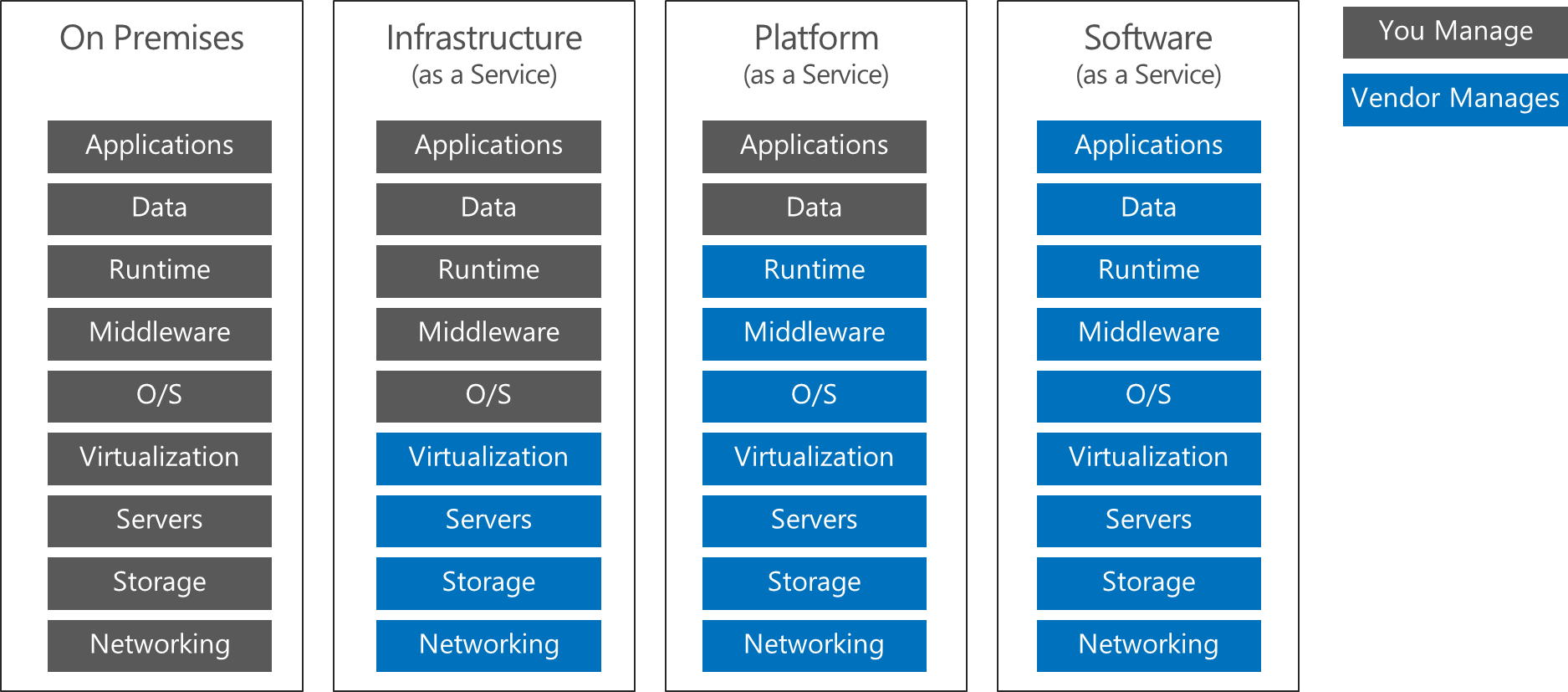


Figure 2. Different types of clouds depend on the level of service that they offer

### Infrastructure as a Service (IaaS)

**Infrastructure as a Service** (IaaS) offers on-demand, highly scalable computing power hosted in large datacenters and delivered over the Internet or an intranet. Customers can order a set of virtual machines (VM) with a set number of CPUs/Cores and amount of memory for a specific time to represent a specific workload. Depending on the cloud service provider, the cloud consumer, e.g. the customer, either gets a pre-installed operating system or can choose from a set of operating systems. The cloud provider takes care of accessibility (network, firewalls, and so on), hardware (including power, cooling, monitoring) and virtual machine provisioning and maintenance. (Some service providers also install and patch the operating systems.)

The customer takes care of everything on top of the infrastructure, such as installing extra software, managing databases, monitoring the operating system and applications, patching software, and more. Often the customer receives administrative rights and full responsibility for the virtual machines.

### Platform as a Service (PaaS)

**Platform as a Service** (PaaS) comprises the aforementioned IaaS characteristics and adds the complete maintenance of the operating system, including patching and monitoring.

Depending on the service provider, PaaS also includes other services such as:

* Development platforms with the native support of various languages such as .NET, Java, Node.js, PHP or Python,
* Middleware oriented services such as ready-to-use message-oriented and/or event-oriented services,
* SQL and/or NoSQL ("not only Structured Query Language") based database services,
* Hadoop services,
* Machine Learning services,
* Etc.

PaaS consumers typically want to deploy and run their own developed or acquired applications on a platform without needing to configure, maintain, and operate that platform.

### Software as a Service (SaaS)

**Software as a Service** (SaaS) goes one step further than PaaS and also offers standard software as an Internet-based service. Examples of SaaS are email systems, instant messaging, conferencing services, collaboration platforms, customer relationship management (CRM) systems, etc. Customers only consume the functions they need, without needing to install, upgrade, patch, monitor, or develop software.

## Different Deployment Models

Another way to classify clouds is by deployment models, which is orthogonal to service models. This typically define who owns and controls the considered cloud. These categories include:

* **Public cloud**.
* **Private cloud**.
* **Community cloud**.
* **Hybrid cloud**.

### Public Cloud

A **public cloud** is one in which “the cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them.”[[9]](#footnote-10) Public clouds usually deliver one or several service models (IaaS, PaaS and SaaS) capabilities over the Internet with the cloud infrastructure shared by many consumers and hosted in large datacenters that offer economies of scale.

### Private Cloud

A **private cloud** is a “cloud infrastructure provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.”[[10]](#footnote-11)

In other words, a private cloud refers to a cloud infrastructure that is dedicated to a single organization (not shared with other organizations). A private cloud can be built and managed by the organization itself, or it can be hosted by another service provider. In the latter case, it is referred to as a *hosted private* *cloud*. A private cloud can be located on-premises or off-premises and consequently be consumed on intranet or over the Internet.

**Note** A single organization might support multiple private clouds. The scale and scope of each cloud is defined by the underlying physical infrastructure and by management decisions. For instance, by a decision to limit access to the cloud to certain sets of users or to provides a high level of security because of local regulations.

In spite of an inherently more limited scale factor, a private cloud has all of the same (kind of) benefits and attributes as the ones expected for a public cloud – plus you also receive a high level of customization which provides the control organizations need to address regulatory privacy and compliance requirements that wouldn’t be possible with a public cloud in some specific cases.

A private cloud requires:

* Virtualization
* A self-service portal
* A significant degree of automation, including deployment and management of virtual machines
* Enough scalability to reallocate resources based on demand
* Automatic failover to other resources if a service component fails

### Community Cloud

In a **community cloud**, the cloud infrastructure is shared by several organizations that share concerns such as similar missions, security requirements, policies, and compliance considerations. The organizations or a third party may manage the cloud, which may exists on-premises or off-premises.[[11]](#footnote-12) The third party might sell excess capacity to and buy additional capacity from other organizations.

### Hybrid Cloud

A **hybrid cloud**, as the name implies, and as previously mentioned, is a combination of “two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).”[[12]](#footnote-13)

In other words, a hybrid cloud consists in leveraging storage, compute, network and other resources and services across clouds.

# The Cloud on Your Term: The Hybrid Cloud

## Opportunities and Challenges of the Public Cloud

As already noticed, the today global economic contraction leads organizations to try driving greater IT efficiency and on the other hand balance this with driving greater business value. According to Gartner[[13]](#footnote-14), the five top priorities in 2013 are indeed in a decreasing order:

1. Increasing enterprise growth,
2. Delivering operation results,
3. Reducing enterprise costs,
4. Attracting and retaining new customers,
5. Improving IT applications and infrastructure.

The first four priorities remain in the five top compared to the ones expressed in 2012 (whilst the fifth one constitutes a new priority).

In such a context, when IT organizations investigate potential cloud services, they will find that public clouds offer inherent capabilities to respond efficiently to the above priorities such as:

* Collaborative, commodity, or E-business/Customers Experience Management (CxM) SaaS solutions,
* Web-based Line-Of-Business (LOB) applications for both custom and general purpose,
* Cloud native applications architected specifically for cloud,
* Disaster Recovery/Business Continuity Management with storage and database replication, failover sites capabilities, etc.
* Batch computing for High Performance Computing (HPC), analytics, modeling, etc.
* Etc.

With a potential mix of SaaS, PaaS and IaaS optimization for applications. Such public cloud services provide turnkey services that can replace internal software.

IT may also be confronted to on-premises complex and critical systems that cannot be migrated at all for a variety of reasons; there is no technical viable migration path, specialized interfaces and communication to external partner systems are required, etc.

To add complexity to the challenges is the need to also ensure compliance to legal, industry and corporate regulations. These challenges vary by the application type and the sensitivity of data. Hence, the public cloud promises are somewhat balanced by the aforementioned constraints that organizations face with, and the above cloud services may not meet the compliance policies and/or the risk tolerance for the business. Thus, organizations would have no other choice than continue to own and operate in-house critical applications and data.

As an example, imagine the business requires a new application over the Internet to enhance the relationships with the customer, and the key points regarding this application are a limited budget and a short time frame to deliver it. In this context, this could lead the IT considering a public cloud solution, which brings interesting capabilities like scale economies, time-to-market and unlimited scalability. But what if some data touched by this application are subject to industry regulations that require for these sensitive data to stay within your organization’s datacenter, the public cloud is no more an option to hold these data.

On the other hand, an on-premises deployment option on a private cloud or on a non-virtualized environment depending on what you have in place could respond to this industry regulation constraint, but it also brings less economies and only a limited scalability. (A private cloud simply aims at bringing the characteristics that have existed in the public cloud for some time into an organization’s customer on-premises datacenter to improve IT efficiency and reduce costs.)

This scenario could possibly result in a solution where these sensitive data rest on-premises (thus responding to the industry regulatory constraint) and (parts of) the application accessing these data could be hosted in the public cloud (thus benefiting from scale economies, time-to-market and unlimited scalability).

The ultimate decision to continue to operate in-house applications and services, to have the most sensitive part of them that remains on-premises, etc. is taken at a precise instant in a given context with some (economical, business, security, compliance, etc.) rationales.

One should consider that organizations evolve over time, reflecting the momentum of their market. In this context of continuous evolution, in his book [Dealing with Darwin](http://www.dealingwithdarwin.com/theBook/introduction.php)[[14]](#footnote-15), Geoffrey Moore deeply delves on the differences between so-called "Core" and “Context" functions: “Core” refers to areas that businesses use to differentiate themselves from their competitors while “Context” corresponds to activities that help businesses achieve the status quo - think operational functions such as HR and Finance. Interestingly enough, all the business functions started out at one time as “Core”. However, over the time, they inevitably fall into the “Context” category essentially because everyone else is doing it and they no longer constitute an area of differentiation. Once a function becomes “Context”, businesses then must put a lot into building new “Core” functions, which will again differentiate them from their competitors. The main difference between organizations that succeed and the ones that fail to evolve over time mostly resides in the fact that those that fail become too occupied with matters that are not at the core of their business. In doing so, they often become too large and bloated and eventually die off.

The same observation applies to IT: some IT functions are “Core” ((parts of) LOB applications, critical systems, etc.) whereas some other IT functions are “Context” (unified communications, collaboration, CRM, etc.). In such a context, IT organizations are already aware of the differentiation between “Core” and “Context” functions and consequently have the willingness to migrate “Context” functions to the public Cloud - unified communications and collaboration functions typically constitute a great illustration. One can predict that as today’s “Core” functions will become tomorrow’s “Context” functions, there is a good chance that these functions will be migrated to the public cloud too.

With the above both on-premises and off-premises deployment opportunities, a new application scenario is created called a hybrid application. This is an application that has parts of the application and data living on-premises with some functionality and data living off-premises in a public cloud. This is often used for applications that may have bursting demand scenarios or in some cases customers looking to share some functionality and data with their suppliers and partners in a cost effective manner. Such applications also typically benefit from specific public cloud augmentations as further discussed later in this paper.

## Business Reasons for Thinking Hybrid

Since private and public clouds have strengths and weaknesses as discussed above, a hybrid approach tends to combine the advantages and to eliminate the weaknesses of both. It’s a continuum between the two.

“Talking about the future of cloud technology, Abhijit Varma, Director, Management Consulting, KPMG said that he expects hybrid cloud to be the route that most companies will take in the medium term.”[[15]](#footnote-16)



Figure 3. The Hybrid Cloud or the continuum

It indeed enables a flexible adoption of public clouds without the need for a big bang and provides in this context a per (part of) application or service opportunity to choose the best sourcing option while requiring potentially relatively little investment and disruption. Moreover, IT can later migrate from hybrid cloud to public cloud at its own pace for different applications and services. As a whole, this results in blurring the distinction between public and private clouds.

Considering the above, a hybrid cloud appears to typically offer distinct benefits, such as to quote a few:

* **Better agility and responsiveness to business needs**. The business is better able to respond to challenges and opportunities with a more agile and responsive IT resource.
* **Reduced total cost of ownership (TCO) with enhanced economics**. Driving higher value from the organization’s existing IT assets. It consists in enhancing and optimizing rather than replacing the current IT infrastructure and enables reusing development and management tooling, proven business processes, etc.
* **Increased business alignment and focus**. The business spends more time and resources on what differentiates it in the marketplace.
* **Improved privacy and compliance**. The approach can satisfy data privacy, industry, etc. regulations by maintaining confidential/sensitive data on-premises and handle Safe Harbor and other compliance requirements.

## Towards An Hybrid IT

“Realizing that the public cloud is not ready to host all applications and data, enterprise IT organizations are beginning to create a hybrid-IT organizational model that helps them choose which applications should go into the public cloud and which should remain in a private cloud.”[[16]](#footnote-17)

We think at Microsoft that this situation in the cloud continuum will result in an equilibrium called the Hybrid IT:

* A state where IT will embrace at the same time traditional non-virtualized systems, private clouds and public clouds.
* A place businesses are going to “call home for a long time to come”.

We indeed believe all organizations are going to have multiple cloud environments: private, public cloud, hosting service providers. Hybrid IT aims at delivering services leveraging resources across traditional and clouds making IT more agile, more responsive of the business. “IT tries to mix and match public clouds and local IT assets to get the best bang for the buck.”[[17]](#footnote-18)

### IT as a Service broker (ITaaSB)

As Gartner analyzes, “Most enterprises that consume cloud services will operate in a hybrid model in which they must secure, manage and govern what is in their environments, as well as external cloud services - including those that have been acquired without IT involvement. Enterprises must deal with application development, delivery and integration patterns that need to be modified to safely exploit this hybrid internal/external, cloud/non-cloud environment… Hybrid IT is emerging as an approach to deal with these complexities; however, hybrid IT does not refer to a particular technological approach or delivery model. Hybrid IT describes a new mission and operational model for IT in a dynamically multisource, heterogeneous world. In hybrid IT, the role of the IT organization is to be the value-added enabler for the most effective and efficient use of services across the enterprise.

Hybrid IT requires that the relationship between the IT department and the business evolve and expand. IT becomes the trusted broker for most, if not all, IT-based services, regardless of provider sourcing or the style of service delivery. In this IT as a Service Broker (ITaaSB) model, IT takes responsibility for service delivery and service levels, even when those services are delivered by other providers. This eliminates the requirement for the enterprise user to be concerned about how a service is being implemented and acquired — enabling them to focus strictly on using the service. As a broker, IT engages with the business to select services, while shielding them from many provider selection, style of computing choice and integration issues. It also ensures compliance with corporate and industry governance requirements.”[[18]](#footnote-19)

The ITaaSB model provides the framework for the service level based agreement between IT and the business stakeholders.

One should note that this model implies a paradigm shift regarding the applications themselves. “The boundary associated with this notion of an application has reached the point of diminishing returns. It does not help modern IT organizations broker a set of shareable components (services) that can be used for a myriad of business solutions.”[[19]](#footnote-20) The delivery of an application will be replaced by the composition of components into services for the business. The provisioning of the entire solution will ultimately correspond to the coordinated instantiation of both internal and external components.

Such an approach improves the service catalog but also adds a bit more complexity to the IT landscape. To manage that complexity, IT should implement a service map. The service map starts with the business services that IT supports and links all the components that are needed to provide each IT service along with their dependencies.

### Cloud Decision Framework

Before reaching the above state that fully leverage the advantages of clouds to improve IT services, augment capabilities, and increase agility while lowering costs, there are a number of considerations that must be evaluated whether to use a private or public cloud for a service or capability. To choose the best option, the organization needs to develop a decision framework and deliver corporate standards and guidelines for each option.

Application and service owners should indeed have a standardized way to deploy (new or refactored) applications and services that includes business logic to decide exactly where to place (parts of) application or component so that a high degree of standardization can be reached at the end for the IT service catalog itself.

It’s all the more so that organizations typically comprise of hundreds of applications that are custom built, acquired from 3rd parties, part of legacy systems, etc. along with different data types and formats, different types of extensibility/states of modifications possible, different application platforms and systems (and even blurred system boundaries), etc. A prior prioritization effort certainly helps in concentrating the efforts on the best return of investment (ROI) application candidates.

Anyway, such a corporate decision framework should notably include an application evaluation process among other constituents such as:

* A **cloud risk assessment model** for instance based on the Cloud Security Alliance (CSA)[[20]](#footnote-21) initiatives such the [Cloud Control Matrix (CCM) v3.0](https://cloudsecurityalliance.org/download/cloud-controls-matrix-v3)[[21]](#footnote-22) and the [Security Guidance for Critical Areas of Focus in Cloud Computing v3.0](https://cloudsecurityalliance.org/download/security-guidance-for-critical-areas-of-focus-in-cloud-computing-v3/)[[22]](#footnote-23) (along with risk mitigation factors),
* A **service provider evaluation process** (service catalog, cost model, service level agreements (SLA), security certifications, etc.),
* **Migration plans** and **contextual related guidance**,
* Etc.

These other constituents are outside the scope of this paper and will not be discussed any further in this paper.

This paper rather focuses on the use case scenarios along with the core paradigms, technical considerations that relate to the applications and services when building them, or when migrating parts of existing on-premises applications to the cloud. Integrating private and public cloud infrastructures indeed brings additional challenges to ensure that (parts of) applications and services can reside at the end in one or either environment while satisfying the regulations for the manipulated data, the technical requirements, supporting the dependencies, etc.

This is the purpose of the next sections.

## Paradigms for Hybrid Cloud

As stated before, hybrid represents a connection or integration between two clouds - usually between an internal private cloud and an external public cloud, but other variation exists such as between a hosting service provider and an external public cloud.

### Cloud Migration vs. Cloud Augmentation

The hybrid paradigm is twofold: Cloud migration vs. Cloud augmentation. As previously mentioned, the need to become leaner and more fit-to-purpose is driving continuous change. As a consequence, organizations:

* Substitute in the former case in-house systems/applications/services (or parts of them) for inexpensive cloud services when they provide the same functionality thus enabling to benefit of a number of inherent characteristics of the Cloud (cost reduction, agility, scalability, etc.).
* Build in the latter case their own systems/applications/services (or parts of them) as cloud services using other (ecosystem) cloud services (API’s) as building blocks. Each resulting “specialized” service can in turn expose a simple API or service façade that allows it to be consumed by another specialized application or service.



Figure 4. An application leveraging “specialized” cloud services

Specialized services hook into other specialized services running anywhere else in the cloud using simple REST APIs. One should mention that cloud platforms that don’t offer this capability will die from “synergy deficiency”.

And the two above tendencies join up.

This enables to multiply usefulness and compete by consuming building block APIs and specializing on what the organization does the best, and/or on what the value proposition resides, i.e. the “Core” functions to recall the above discussions on hybrid IT.

### “Hybrid at the same time” vs. “Hybrid over the time”

Moreover, the hybrid paradigm can also be envisaged according the following two categories for an IT service: “hybrid at the same time” vs. “hybrid over the time”. In the former case, an IT service is instantiated as parts of it both on-premises and off-premises (hosting service provider, public cloud). This enables to operate sensitive processes and tasks on-premises on traditional non-virtualized systems or on a private cloud whilst the rest of services runs off-premises. In the latter case, as one can imagine, the IT service can be deployed as a workload first on the public cloud and then moved to the private cloud or vice versa.

## Use Case Scenarios for Hybrid Cloud

Taken the above considerations and paradigms into account, hybrid clouds enable a variety of (families of) use case scenarios, including in a non-exhaustive manner:

* **Development, testing, and pre-Production (DevTests)**.
* **Temporary projects**.
* **On-premises applications integrated with off-premises services**.
* **Off-premises applications integrated with on-premises services**.
* **Off-premises applications integrated with data stored on-premises**.
* **Cloud as (message/event-oriented) integration/ingestion hub**.
* **Global content delivery**.
* **Choice of service level**.
* **Burst capacity extension/Datacenter replacement**.
* **Cloud as cost-effective Storage**.
* **Backup and recovery**.
* **Disaster recovery/Business continuity management**.

The above (families of) use case scenarios and related business reasons as developed hereafter.

### Development, Testing, and Preproduction (DevTests)

The first use case scenario we’d like to outline consists in leveraging hybrid cloud for development, testing, and preproduction. The project is typically developed or tested in one environment and then move to the other one.



Figure 5. Development and test environment via cloud services

A **develop in the cloud then move to on-premises** approach can indeed be adopted where the public cloud environment resources are only used for the duration the project. This enables to develop and/or evaluate software, conduct integration tests, predict usage/capacity, host infrastructure and applications during planned local downtime/outages, etc.

The development and/or testing environments have fewer service-level requirements compared to production environments. It is therefore wise to rely on cloud services to provide such environments, because of their temporary nature (resources can be decommissioned after the project). The ability to keep a snapshot of the development and test environments for later use for improvement or bug fixing projects is also a consideration.

A **develop on-premises and then move to the cloud** approach can also be envisaged for the same reasons depending on the workload and its usage profile. Both approaches are valid for this scenario.

### Temporary Projects

A variation of the previous use case scenario consists in executing temporary workloads on a public cloud along with infrastructure services running onsite or on a private cloud. PAYG capabilities can be leveraged by IT for business.

### On-premises Applications Integrated with Off-premises Services

As previously mentioned in terms of hybrid paradigm, IT services directly benefit from specific public cloud augmentations. A common scenario for public cloud augmentations consists in augmenting traditional non-virtualized services and/or private cloud services with unique public cloud services provided by public cloud providers as SaaS or developed by the organization and run in the public cloud as PaaS.



Figure 6. On-premises applications integrated with scalable cloud service

Examples of (scalable) public cloud services in this scenario are multi-providers and/or multi-protocols authentication (gateway) services, document electronic signing services, credit card services provided by credit card companies, data feeds such as news or real-time foreign exchange rates, push notification services for mobile devices, etc. These services can be transparently integrated into the organization’s service catalog via the public cloud.

One example of a way to leverage PaaS offerings would be using a PaaS public cloud as a suitable way in order to enhance the accessibility of legacy applications in the context of mobility. On-premises applications have traditionally been designed and implemented for local users on the corporate network or remote users via a VPN access. Mobility is today characterized by the explosion of devices of various form-factors (smartphones, tablets and hybrid laptops). Mobility is also characterized by the ubiquity of broadband networks giving rise to the “always connected” devices able to consume information and Internet services from anywhere at any moment. And finally, mobility is characterized by the consumerization of IT (CoIT) whereby these consumer-oriented devices are increasingly penetrating the enterprise world.

Whether these devices result from a Bring Your Own Device (BYOD) strategy or are corporate owned, personally enabled (COPE) devices, they break the frontiers between personal and professional universes, and thus consequently impact the organization IT infrastructure that was not originally designed to accommodate and integrate personal devices.

Mobile devices benefits from their access to ubiquitous broadband networks to consume cloud computing services delivered over the Internet wire. Meaning that information workers (and even consumers) can henceforth access corporate assets and information from their mobile devices through cloud applications and services.

Consequently, suitable ways in order to enhance the accessibility of legacy applications might be to:

* Either provision a web-based front-end hosted in the cloud that integrates with the on-premises legacy application.
* Or develop front-end application(s) for mobile devices that integrates with back-end services provisioned in cloud, which in turn integrate with the on-premises legacy application.



Figure 7. Enabling mobile users

Another example would be to outsource compute-intensive custom application components to a PaaS public cloud while the main application remains on-premises. Typical candidates for such a configuration would be complex simulations or data analyses that require manipulation of Big Data and provide just the results or insights back to the on-premises application. The key aspect is that all data and analysis remains in the public cloud where it can best be aggregated and processed with the final results being securely stored on-premises.

### Off-premises Applications integrated with On-premises Services

Another typical scenario that simultaneously combines cloud and on-premises services is one in which the scalability and Internet accessibility of the public cloud is leveraged and integrated with on-premises services.

Examples of this configuration include the use of SaaS offerings such as Customer Relationship Management (CRM) services with integration to on-site applications such as Enterprise Resource Planning (ERP) systems, unified communication and collaboration services for email, calendaring, voicemail, and management systems integrated with local directories, vacation request tools, travel and expense services, or any other custom developed service.

Another hybrid cloud scenario aims at:

* Developing a web-based frond-end application that requires some information from other applications and/or services that are hosted on-premises.
* Or conversely moving a website to a public cloud-based PaaS for cost savings and agility, whilst processing the collected/submitted information on-premises.

Such an approach represents a clever way to deal with governance, risk management, and compliance (GRC).



Figure 8. Scalable cloud front-end application integrated to local on-premises service

### Off-premises Applications integrated with Data stored On-premises

A variation of the previous scenarios consists in using cloud-based applications that leverage data that must remain on-premises. This typically comprises in a non-exhaustive manner:

* Highly sensitive business material such as financial data and intellectual property.
* Assets subjected to specific (privacy) regulatory requirements.

This scenario combines the benefits of public clouds, such as elasticity and cost efficiency, with the special requirements of confidential/sensitive data.



Figure 9. Cloud front-end application integrated with confidential data stored on-premises

### Cloud as Integration/ingestion Hub

PaaS Public cloud offerings can provide an integration/ingestion layer such as:

* Message-oriented services that can be leveraged to easily integrate with other collaboration partners, suppliers, etc. in a standardized way without the need to rebuild on-premises connectivity, message transformation, and routing capabilities.



Figure 10. Cloud service as integration enabler between different collaboration partners

The cloud-provided integration/ingestion layer can be also used to securely publish on-premises services to the outside as rendezvous endpoints without even having to alter the firewall configuration.

* Event-oriented services that can be leveraged to smoothly sustain an Internet of Things (IoT) strategy.

The cloud-provided integration/ingestion layer can be used in this context as a highly scalable publish-subscribe event ingestor that can intake millions of events per second in order to further process and analyze the massive amounts of data produced by your connected devices, objects, and applications. Once collected, the layer typically enables you transform and store data using a real-time analytics provider or with batching/storage adapters.

### Global Content Delivery

This use case scenario aims at leveraging cloud services to distribute systems and data to multiple geographic locations in order to improve end-user performances globally and/or to facilitate global support.

It may additionally require provisioning workloads (information) and data from the on-premises to one cloud datacenter that will serve as a hub to further replicate/synchronize workloads (information) and data to the several datacenters around the world of the cloud provider that deliver the considered cloud services.

### Choice of Service Level

Another use case scenario consists in provisioning two similar services with different service levels and associated costs. This flexible deployment allows the service consumer or the business to then decide which service level and cost model to choose for on-demand allocation.



Figure 11. Different service levels, such as high-cost and/or high-confidentiality vs. low-cost and/or low-confidentiality

Examples of this scenario include SaaS services such as collaboration and communication (mailboxes and chat for instance) capabilities that are provided on-premises in a higher-cost but highly confidential way for VIPs and knowledge/information workers and off-premises as a less-expensive and less-confidential public service for task workers.

This scenario applies for PaaS offerings as well, i.e. executing sensitive workloads on-premises on a private cloud and the others on public clouds. In other words, the higher-cost and/or high-confidentiality applications run on-premises while lower-cost and/or less-confidential applications are hosted on the public cloud (possibly with reduced service levels).

Eventually, this also applies for IaaS offerings where virtual machine (VM) from a set of templates (various sizes, operating systems, and configurations) or more complex workloads based on them can be provided parallel on-premises and on public cloud(s) with different service levels and prices. These VM provide computing and storage capabilities and allow installation of commercial off-the-shelf (COTS) and custom software.

### Burst Capacity Extension/Datacenter Replacement

A key characteristic of cloud computing is the quick elasticity that it provides. This elasticity provides the ability to accommodate the following hybrid cloud scenario: An on-premises application designed for a certain average load can be temporarily enhanced by expanding current capacity requirements (cloud bursting) in case of predicted additional load. When the need for extra computing power is over, the extra IT resources can be decommissioned to reduce the costs.



Figure 12. Burst capacity extension to handle peak loads

Examples of such use case scenarios are increased loads on websites because of public events well as fixed yearly dates such as Christmas or as due dates for filing tax forms for instance. This scenario doesn’t only apply to web-based sites; temporary virtual machines could also be added for data processing and any other workloads.

Furthermore, such scenario can also ease the reduction or replacement of a datacenter.

### Cloud as Cost Effective Storage

This use case scenario aims at using of on-premises applications enhanced with cost effective and easily scalable storage in the cloud. Such a configuration might be reasonable for large files such as CAD drawings, images, videos, etc. it’s all the more so that built-in redundancy is generally provided for such data storage.



Figure 13. Cloud as cost effective storage for on-premises applications

It enables to move for instance an entire media library with thousands of large files to cloud storage for improved streaming purposes and decreased footprint in the on-premises infrastructure. To improve the streaming performance in such scenarios, additional capabilities can typically be leveraged (if any suitable) for close-to-consumer caching. For instance, content delivery networks (CDNs) “edge nodes” can help address bandwidth and latency challenges.

Moreover, with the Open Data movement dynamics, governments, government agencies (and even private companies) publish every day more data (sets) on the Internet. Sharing this data enables greater transparency, helps delivering more efficient (public) services, and encourages greater public and commercial use and re-use of the publicly made available information in new and innovative ways. To create (the catalogs of) these data sets, the cloud can also represent a cost effective storage in this context. Data sets are sourced from on-premises applications and related data repositories with manual or automated process. (A portal (along with a RESTful based data service or dedicated API’s) can also be created in the cloud to make it easy for citizens, data journalists, researchers, companies, independent developers, etc. to find, query and consume this information (in new and innovative ways).)

Similarly, another example would be for:

* Harvesting and storing the “data deluge” faced today by organizations with the various sensors, devices, robots, etc. – data can be exchanges on social networks, contents of Web pages, Web server logs, urban traffic information, banking, data on financial markets, satellite imagery, audio streams, GPS track log files, etc.
* And later analyzing large data sets - so-called Big Data – to extract useful insights for business, which are then provided back to on-premises applications and systems (see above section § On-premises Applications Integrated with Off-premises Service).

### Backup and Recovery

A variation of the previously mentioned use case scenario consists in using a cloud as backup information of on-premises (or of another cloud). In terms of recovery, one can then connect clouds to backup information to different geographic locations or even across providers.

### Disaster Recovery/Business Continuity Management

Many organizations are interested in connecting with cloud services to offer Disaster Recovery (DR)/Business Continuity Management (BCM) solutions through replication, workload mobility, or agile deployment of infrastructure in connecting with cloud services to offer DR/BCM solutions through replication, workload mobility, or agile deployment of infrastructure. It’s often important to get a DR site up quickly and cost-efficiently, so using a public cloud might be a suitable alternative to high-cost DR plans.

In the **Cloud as disaster recovery site** scenario, the workloads run on-premises with the ability to switch to the public cloud if needed. For that purpose, the backups or snapshots of the most important workloads - mainly virtual machines (VMs) and databases - are replicated in an (encrypted) way to the public cloud. If a disaster occurs, these replicas can then be (decrypted and) mounted in the IaaS public cloud environment to provide a quick restoration of the most critical services.



Figure 14. Cloud as disaster recovery site

Conversely, depending on the workloads and their usage profile(s), one should note that the reverse scenario **On-premises as recovery site** can also be considered where the workloads runs on the public clouds with the ability to switch to on-premises on a private cloud if needed.

## Additional Considerations for Hybrid Cloud

Applications (and ultimately IT service) that span the on-premises (on traditional non-virtualized system(s) and/or private cloud infrastructure(s)) and the public cloud(s) indeed bring with them a unique set of challenges and considerations that must be addressed.

Most applications today are not simple; they may consist of many separate features that are implemented as services, components, third-party plug-ins, and other systems or resources. Integrating these items when all of the components are hosted locally in your datacenter is not a trivial task, and it can become even more of a challenge when you move parts of the application to a cloud-based environment.

“By evaluating factors such as application technical requirements, application dependencies, application migration costs, application portability or rewrite requirements, and current development skills, IT organizations can make an informed decision as to how to move an application to the cloud and where to host the application (that is, SaaS, PaaS or IaaS). For instance, evaluating the application's technical requirements (such as storage, network, OS or application platform requirements) helps answer questions such as "How much will this application cost to rehost in IaaS?" or "Does the application need a slight revising to host it in PaaS?" Knowing the answers to these questions will help IT organizations determine the effort and resources required to host the application in the public cloud.”[[23]](#footnote-24)

It is often helpful to divide the challenges and considerations presented by (parts of) an application into distinct categories that focus attention on the fundamental areas of concern. This is the purpose of the following sections.

### Deploying Functionality and Data to the Cloud

When planning to move parts of an existing application from on-premises to the cloud, it is likely that you will need to modify the code in the existing on-premises components, features, services, etc. of the applications to some extent before it, and the data it uses, can be deployed to the cloud.

At a minimum you will need to modify the configuration, and you may also need to rehost, refactor, revise, rebuild or replace - to refer to the Gartner’s application migration patterns to cloud computing[[24]](#footnote-25) - the code of the moving parts so that it runs in the public cloud.

You must also consider how you will deploy data to the cloud; and handle applications that, for a variety of reasons, may not be suitable for deploying to the public cloud.

To determine whether to use a public or private cloud, an organization must comply with the security policy in place along with all relevant regulations (privacy, industry, etc.) for the assets that it manages. Consequently, an information classification effort constitutes a mandatory starting point.

**Information classification has to be conducted as a joined cross-functional effort between:**

* **IT professionals,**
* **Executives or key representatives from the business side of the organization who have a strong understanding of the business along with a clear understanding of any compliance, industry or government regulations with which their data must comply,**
* **The stakeholders from across the organization,**
* **And of course the corporate legal department.**

Indeed, "classification facilitates understanding of data's value and characteristics. The value of data is relevant to each individual business and is determined by that business unit; an IT organization is unlikely to have any insight.”[[25]](#footnote-26)

Information classification aims at analyzing information to determine into which of predefined classification level it falls to then apply in turn the right security control according the security and privacy standards. Consequently, organizations need to find ways to categorize information that make sense for their business, organizational, conformance, and legal requirements.

Nevertheless, the classification effort should result in having **as few information classification levels as possible.** Simple is obviously better notably in terms of manageability and applicability of the required controls to ensure the security and the privacy of the information.

**Three classification levels are generally considered the minimum to allow for:**

* **Company confidential (high, restricted)**. Information assets classified to this level typically include data where disclosure to unauthorized parties could cause severe or catastrophic material loss to one or more individuals like the information asset owner, the organization, and/or relying parties. Access to such assets are frequently strictly controlled and limited for use on a “need to know” basis only.
* **Internal use only (medium, sensitive)**. Information assets classified to this level include data where unauthorized or improperly disclosure, loss or destruction may cause limited material loss to individual(s), the organization, and/or relying parties due to identity/brand damage, operational disruptions, and or legal/regulatory liability. Access to such assets are frequently limited for use by only those who have a legitimate business need for access.
* **Public (low, unrestricted)**. Information assets classified to this level include data where unauthorized or improperly disclosure could result in limited to no material loss to the organization, individual(s), or relying parties. These assets are typically intended to be widely published or disseminated and have minimal consequences if improperly disclosed.

### Authentication, Authorization, and Access

Most applications need to authenticate and authorize full time employees (FTE), contractors, business partners, or even customers at some stage of the process (if it’s not at the very beginning). Whilst authentication was traditionally carried out against a local application-specific store – one should say identity silo - of user information, the application may alternatively need to authenticate using accounts against the corporate on-premises identity infrastructure to allow single sign-on (SSO) and/or to support federated identity with partners.

Furthermore, with the desire to better collaborate a la Facebook with the “social” enterprise, the need to support and integrate with social networks, etc. which all lead to a Bring Your Own Identity (BYOI) trend, users increasingly expect applications to allow them to use more universal credentials; for instance, existing accounts with social network or popular web identity providers such as Microsoft Account (formerly known as Windows Live ID), Google, Facebook, or any Open ID identity provider.

When parts of the application are now running in a remote location, identity management should happen across environments and security boundaries. A single identity management mechanism, standard processes, and logic should apply in the hybrid environment to ensure that identity and access control management is still done in accordance to the corporate security policies, the regulations in place, etc.

Moreover, the end location of the parts (components, features, etc.) of the application must be somehow transparent to users granting them the seamless possible experience.

In other words, a holistic identity and access management system that encompasses security boundaries is required. It should allow users to seamlessly access on-premises and public services without realizing where the service is hosted (single sign-on or at least single ID/password). Such capability can be provided at the minimum by what is called by Gartner an “identity bridge”.

“The identity bridge is a new concept, and one that will continue to evolve as organizations embrace hybrid cloud architectures and software as a service (SaaS) applications. Identity bridges are on-premises appliances that enable identity services across a hybrid computing infrastructure. Those identity services include directory synchronization, federation, just in time (JIT) provisioning, mobile credential management, traditional provisioning, Web access management (WAM).”[[26]](#footnote-27)

Identity becomes a service where identity “bridges” on-premises or in the cloud, “talk” to on-premises directories or the directories themselves move and/or are located in the cloud.[[27]](#footnote-28)

As a result, we are more and more going to such capability leveraging an Identity Management as a Service (IDaaS) service in the cloud, i.e. a directory in the cloud that provides a robust and comprehensive cloud identity platform architected to operate in the cloud with high scale, high availability, and integrated disaster recovery.

### Cross-boundary Communication and Service Access

It is common for an application to contain some components or features that cannot be located in the cloud, such as third-party services or sensitive data that must be maintained onsite under specialist control.

When planning to move parts of an existing application from on-premises to the cloud, it is likely that you will have concerns centered on issues such as communication and connectivity.

When parts of the application are now running in a remote location, and are accessible only over the Internet, many operations performed in the application must then cross the boundary between on-premises components, features, services, partner organizations services, and components and services hosted in the public cloud. Can they still work successfully as part of the overall application? For instance, how will cloud-based parts of the application call on-premises components and services, or send messages to on-premises services? How will cloud-based parts of the application access data in on-premises data stores? How can you ensure that all instances of the (parts of) application running in cloud datacenters have data that is up-to-date?

It is fundamental that the communication between environments is reliable and responsive. Service calls and messages must be able to pass through firewalls and Network Address Translation (NAT) routers if any without compromising on-premises security.

The communication mechanisms, which do not necessarily rely on a VPN, must work well over the Internet and compensate for lower bandwidth, higher latency, and less reliable connectivity. External datacenters are almost always further away than an organization’s own datacenters, which can affect the performance of a network service. An organization should take this network latency into consideration and validate on a case-by-case basis to determine which parts of the application to move to a public cloud and how. For instance, “chatty” applications with multiple calls from on-premises computers to the public cloud are not the best candidates for a hybrid cloud. Bandwidth-intense applications, on the other hand, are good candidates to outsource to external datacenters to reduce the network load on an organization’s own datacenters. Content delivery networks (CDNs) “edge nodes” can help address bandwidth and latency challenges.

The communication mechanisms must also protect the contents of messages, authenticate senders, and protect the services and endpoints from Denial of Service (DoS) attacks.

### Business Logic and Message Routing

Many Line-Of-Business (LOB) applications must process business rules or workflows that contain conditional tests, and which result in different actions based on the results of evaluating these rules. For instance, an application may need to update a database, send the order to the business partner, perform auditing operations on the content of the order, and store the order in another database for accounting purposes.

When moving parts of the application to the cloud, these operations may involve services and resources located both in the cloud and on-premises.

### Data Synchronization

Required in many scenarios such as disaster recovery or by hybrid applications that run partly on-premises and partly in the cloud, run in the cloud and use on-premises data, or run wholly in the cloud but in more than one datacenter, data must be synchronized and replicated between locations and across network boundaries. This must be performed consistently across different environments.

Depending on how data is stored, the sensitivity of the data, this may involve synchronizing only some rows and columns, and you may also want to perform translations on the data.

### Scalability, Performance and Availability

Moving parts of an application to the cloud inevitably asks questions about scalability performance, availability. How can performance and availability be maximized when some parts of the application are located in the cloud?

Metrics for these factors are important for IT. Services and applications deployed in a hybrid cloud should comply with the same metrics for scalability, performance, and availability even though they’re deployed, managed, and supported differently.

While cloud platforms provide scalability and reliability, the division of parts of the application across the cloud/on-premises boundary may cause performance issues. Bandwidth limitations, the use of “chatty” interfaces, and the possibility of throttling in the public cloud may necessitate caching data at appropriate locations, deploying additional instances of the cloud-based parts of the application to handle varying load and to protect against transient network problems, and providing instances that are close to the users to minimize response times.

### Monitoring and Management

In hybrid cloud solutions, the private cloud is usually owned by the organizations themselves which apply their own methodology and processes for monitoring and management, similarly to what is enforced on traditional non-virtualized systems. In the public cloud, the cloud provider usually owns a part of the application and provides ownership to the service consumer, i.e. the organization, for the rest of the stack.

Nevertheless, organizations must be able to effectively manage their remote cloud-hosted parts of the applications, monitor the day-to-day operation of these components and services, and have access to logging and auditing data. They must also be able to configure, upgrade, and administer them, just as they would if they were (still) running in a corporate on-premises datacenter. Organizations also need to obtain relevant and timely business information from these remote components and services of the applications to ensure that they are meeting current requirements such as SLAs, and to plan for the future.

It’s most efficient to have a common approach on monitoring and management for both on-premises and public cloud(s). The IT monitoring strategy indeed needs to grow and adapt to applications, services, solution component, and infrastructure despite whether they reside on-premises on traditional non-virtualized systems, on private cloud(s) or on public cloud(s). Same is true for monitoring capabilities that should span network boundaries between the on-premises public clouds to provide segregated, aggregated reports and monitoring views for (parts of) applications and services.

A typical list of requirements for reporting and monitoring includes:

* Multi-tenancy model implementation monitoring and reporting.
* Application level monitoring.
* Multi-tier monitoring services.
* Chargeback and billing - resources use metrics per business, service, application, and component reporting.
* Integrated dashboards and reports.

### Global Support

Because the number of parties involved typically increases in a hybrid cloud setup, an organization should clearly define its responsibilities and support channels.

Such efforts should include signing a support contract with each public cloud provider, defining first, second, and third-level support organizations, establishing an escalation strategy, and monitoring the (parts of) application and solution components, the dependencies, and providers to involve the right support channels quickly if an incident occurs.

It’s also important to clearly communicate the terms of SLAs to business units so they know what to expect.

# Microsoft Hybrid IT Approach

For today’s CIOs and technology leaders, the cloud presents an opportunity to rethink the role IT plays in defining a business strategy. Because of its power to fundamentally change how businesses operate and compete, the cloud is a game changer for the enterprise. We think of it as a key step toward helping our customers achieve better business agility, economics, and user experiences.

Microsoft believes the hybrid cloud is key to helping you optimize your business and we are more than convinced that the aforementioned use case scenarios mixing traditional non-virtualized systems, private clouds and public clouds will be very common in your businesses if not already.

We are working with businesses to reimagine their IT with the most comprehensive cloud offerings of any vendor (spanning public and private cloud), decades of experience in the enterprise, and over 15 years of offering cloud services to consumers and businesses. The vision that sustains the Microsoft Hybrid IT approach is what we call the **“Cloud OS Vision”**, i.e. a differentiated approach that will help organizations embrace the transformational changes happening now.

**Note** For additional information, see the eponym blog post [Cloud OS Vision](http://www.microsoft.com/en-us/server-cloud/cloud-os/default.aspx)[[28]](#footnote-29).

Our $15 billion investment in global datacenter infrastructure with [Microsoft Global Foundation Services (GFS)](http://www.globalfoundationservices.com)[[29]](#footnote-30), i.e. the engine that powers Microsoft cloud services, our extensive ecosystem of partners and developers, etc. uniquely underscore the peace of mind Microsoft cloud services provide.

**Note** Microsoft has been building and managing datacenters for over 25 years. Global Foundation Services deliver the core infrastructure and foundational technologies for more than 200 Microsoft online businesses, including Bing, MSN, Office 365, Xbox Live, Skype, OneDrive, and, of course, Microsoft Azure. The cloud datacenter infrastructure is comprised of many hundreds of thousands of servers, content distribution networks, edge computing nodes, and fiber optic networks.

As a result, with a virtuous cycle of development, Microsoft Hybrid IT approach is unsurprisingly comprehensive, spanning from public to private clouds, enabling you to use a hybrid cloud in your own way, at your own pace, no matter what form of hybrid cloud you choose to deploy, and helping you at the end to deliver Hybrid IT within your organization. It aims at delivering ITaaSB on your terms with flexible, management across your hybrid environments.

Practically speaking, the above vision “means your organization can shift to more efficiently managing datacenter resources as a whole, including networking, storage and compute. You will be able to deliver powerful apps that boost employee productivity and delight your customers much, much faster across private, hybrid and public clouds.

Furthermore, it means you can manage data, both big and small, to extract the story it has to tell for your business. And you will be able to give employees personalized experiences with apps and data on virtually any device, while maintaining security and compliance.” [[30]](#footnote-31)

## Deployment Choice for the Cloud

Microsoft is in a unique position as Cloud Service Provider for public clouds in so far we offer the whole range of service models: IaaS, PaaS, and SaaS.

Indeed, as a non-exhaustive illustration, we can mention the following Microsoft Online Services:

* [**Microsoft Azure**](http://www.microsoft.com/azure)**[[31]](#footnote-32)**. Microsoft Azure is a flexible and open cloud computing platform hosted in Microsoft datacenters delivering scalable and reliable Internet-scale services. As an IaaS platform (Infrastructure Services), it enables you to deploy (complex) workloads (servers, networking and storage infrastructure) in the cloud that you can control and manage on your terms.

Also, as a PaaS platform, it includes a number of features, which can be used individually or composed together in a public or hybrid cloud fashion. As illustrated hereafter, the Azure services catalog comprises compute, data, and application capabilities/augmentations for web sites, mobile back-ends, event ingestion and messaging, (hybrid) identity, SQL/ NoSQL database, machine learning, caching, etc. which can be directly consumed and integrated in your solutions regardless where they reside.

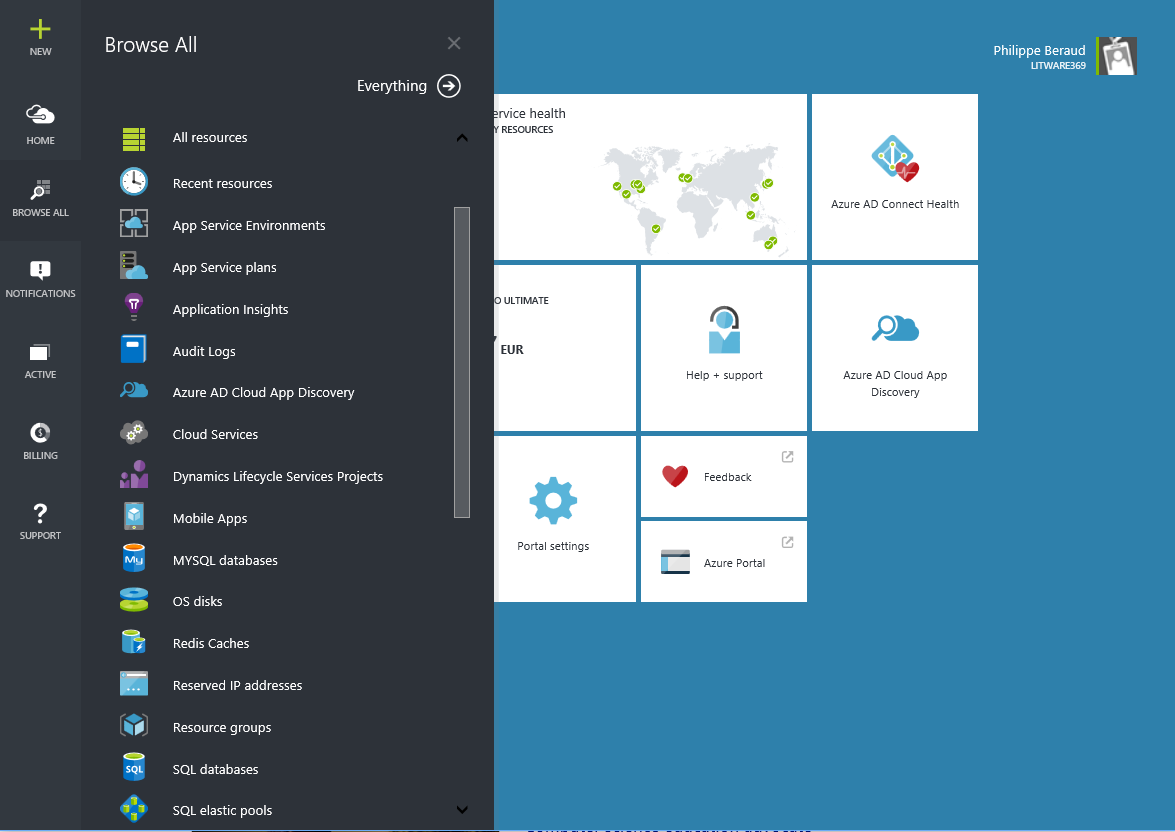


Figure 15. View of the Microsoft Azure Preview Portal and associated resources.

Available in 141 countries, including China, and supporting 10 languages and 19 currencies, all backed by the aforementioned massive Microsoft's investment in global datacenter infrastructure, Microsoft Azure is continuously investing in the latest infrastructure technologies, with a focus on high reliability, operational excellence, cost-effectiveness, environmental sustainability, and a trustworthy online experience for customers and partners worldwide.

The [infographic](http://azure.microsoft.com/en-us/documentation/infographics/azure/)[[32]](#footnote-33) below provides you with an overview of Azure features, services that Microsoft Azure brings to your fingertips in a reliable, secure, and environmentally sustainable way along with their common uses. You can do immense things with Azure, such as create a single VM with 32TB of storage driving more than 50,000 IOPS, utilize hundreds of thousands of CPU cores to solve your most difficult computational problems, and far more.

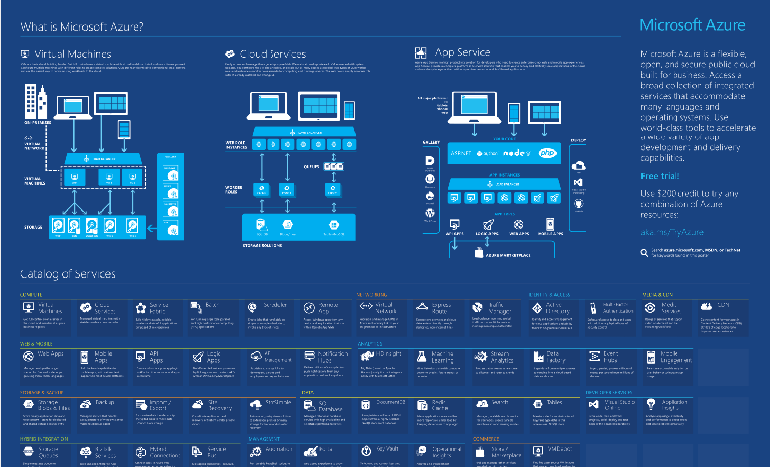


Figure 16. View of the of Azure features, services, and common uses.

**Note** For an introduction to the above wide range of capabilities in Azure, see the free eBook [Microsoft Azure Essentials: Fundamentals of Azure](http://aka.ms/697225pdf)[[33]](#footnote-34).This eBook provides conceptual and how-to content for seven key areas and describe management tools and business cases. It is part of the “Microsoft Azure Essentials” series that helps you advance your technical skills with Microsoft Azure.

* [**Microsoft Office 365**](http://www.microsoft.com/office365)[[34]](#footnote-35). Office 365 provides secure anywhere access to business-class email, shared calendars, instant messaging (IM) and Skype connectivity, voicemail integration (Unified Messaging), online conferencing, document collaboration, team sites, site mailboxes, enterprise social, file storage and sharing, and self-service Business intelligence (BI).

Available in 140 countries, including China, and supporting 43 languages and 25 currencies, Office 365 represents, for businesses of all sizes, the cloud version of the Microsoft communication and collaboration products along with Office on any device, i.e. the stream full versions of Office desktop suite, and Office on more devices for consistent and familiar Office experience across PCs, Macs, Windows tablets, iOS mobile devices, and Android mobile devices.

Depending on the plans, Office 365 indeed includes Office Online, Exchange Online, SharePoint Online, Skype for Business (formerly Lync Online), OneDrive for Business, Yammer, Power BI for Office 365, and Video.

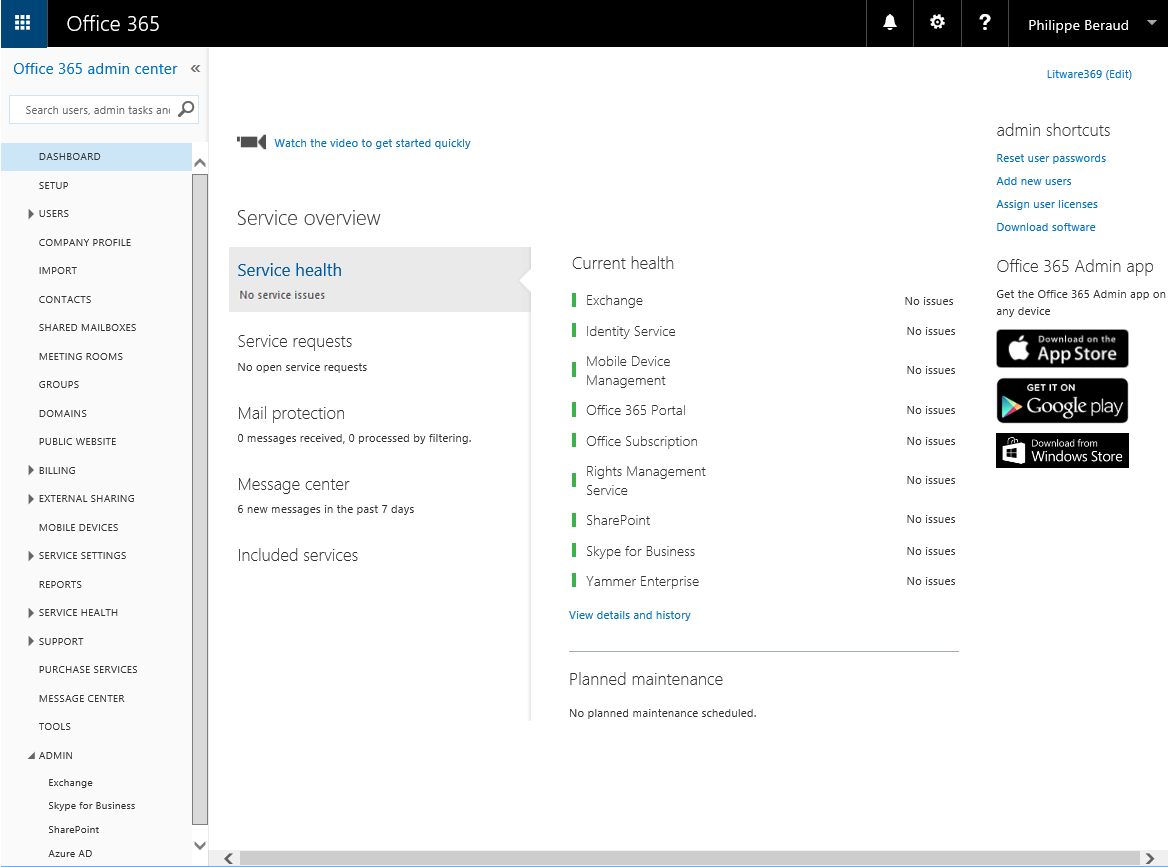


Figure 17. View of the Office 365 Admin Center Web-based Dashboard

Likewise, Microsoft is providing a complete offering in terms of private cloud. As stated before, a private cloud transforms the way your business delivers and consumes IT services. By creating a layer of abstraction over pooled resources, a private cloud enables true service capability as well as optimally managed application services.

[**Microsoft private cloud solutions**](http://www.microsoft.com/privatecloud)[[35]](#footnote-36) are anchored with a cloud-optimized operating system and management solution, Microsoft Windows Server and System Center technologies – the combination that provides enterprise class virtualization, end-to-end service management and deep insight into applications so that you can focus more attention on delivering business value in the world of hybrid IT.

They are offered as custom, pre-configured, or hosted offering – so, no matter your unique business need; there is a Microsoft private solution for it.

**Note** For additional detail, see the white paper [Microsoft Private Cloud – Making It Real](http://download.microsoft.com/download/1/0/7/107D3951-9732-421D-8B57-AC19530F24D1/Private%20Cloud%20Making%20It%20Real.pdf)[[36]](#footnote-37).

## Commonalities Spanning Private and Public Clouds

“Microsoft is uniquely positioned to deliver on the promise of the Cloud OS is that our products and services are deeply informed by our first-hand experience in running some of the largest Internet-scale services in the world. Running more than 200 cloud services for over 1 billion customers and 20+ million businesses around the world has taught us – and teaches us in real time – what it takes to architect, build and run applications and services at cloud scale.”[[37]](#footnote-38)

Microsoft offers solutions that span both the public and private clouds with notably Windows Server and Azure but not only. “Our breadth of experience across private, public and hybrid cloud is unmatched, whereas other vendors tend to specialize in one or another area.”[[38]](#footnote-39)

At the beginning of last year, Microsoft started to announce several products and services that deliver against the aforementioned Cloud OS vision. The rest of this section will cover them to provide you with an understanding of what Cloud OS is and means for you and your organization.

**Important note** The [Build 2015](http://channel9.msdn.com/events/build/2015)[[39]](#footnote-40) and [Ignite 2015](http://channel9.msdn.com/events/ignite/2015)[[40]](#footnote-41) conferences earlier this year have been the occasion to continue on this trend with at the heart the announcement of Azure Stack and the Azure Service Fabric.

Azure Stack is all about bringing Azure to your datacenter, equipping you to transform your organization. Azure Stack will be available as part of the 2016 wave of products. For additional information, see the blog posts [Announcing the Microsoft Azure Stack](http://blogs.technet.com/b/server-cloud/archive/2015/05/04/announcing-microsoft-azure-stack.aspx)[[41]](#footnote-42) and the dedicated [web site](http://www.microsoft.com/en-us/server-cloud/products/azure-in-your-datacenter/)[[42]](#footnote-43).

Azure Service Fabric on the other hand enables building highly scalable, reliable, and easily managed applications composed of micro-services, i.e. highly scalable, resilient, and composable units of deployment for such applications. Azure Service Fabric is available as a developer preview that you can download and work with in your on-premises environment. For additional information, see the blog posts [Announcing Azure Service Fabric: Reducing Complexity in a Hyper-scale World](http://azure.microsoft.com/blog/2015/04/20/announcing-azure-service-fabric-reducing-complexity-in-a-hyper-scale-world/)[[43]](#footnote-44), the dedicated [web site](http://azure.microsoft.com/en-us/campaigns/service-fabric/)[[44]](#footnote-45), and the Microsoft MSDN [online documentation](http://azure.microsoft.com/en-us/documentation/services/service-fabric/)[[45]](#footnote-46).

This document will be updated to reflect these major evolutions once generally available. For the moment and for those interested in our Cloud OS vision, you can start the journey by trying the new Azure Portal Preview and Azure Resource Manager, and/or with Windows Server 2012 R2, System Center 2012 R2, and the Azure Pack as covered in this document.

**At the highest level, the Cloud OS does what a traditional operating system does – manage applications and hardware – but at the scope and scale of cloud computing.** The foundations of the Cloud OS are Windows Server and Azure, complemented by the full breadth of our technology solutions, such as System Center and Visual Studio.

Because you may have investments that span traditional on-premises, private, hosted and public cloud environments, together, these technologies provide one comprehensive and consistent platform for infrastructure, apps and data that can span your datacenter with traditional non-virtualized systems and/or private cloud(s), hosting service provider datacenters, and the Microsoft public cloud.

**Note** For additional information, see the blog post [Microsoft and Service Providers Deliver on the Cloud OS Vision Together](http://blogs.technet.com/b/hosting/archive/2013/01/15/microsoft-and-service-providers-deliver-on-the-cloud-os-vision-together.aspx)[[46]](#footnote-47).

The pursued goal aims at providing a common and consistent set of infrastructure including identity, virtualization, management, and developer tools that work and extend across those three datacenter layers and provide symmetry between them, so that your organization’s investments today will carry them into the future, no matter what form of hybrid cloud they choose to deploy for their IT services:

* **(Hybrid) Identity**. Active Directory and Azure Active Directory provide a powerful base for single identity across clouds to securely extend applications to people and their devices.
* **Virtualization**. Integrated and portable virtualization, built into Windows Server and Azure, allows to virtualize not just servers, but also the network, storage and applications across clouds.
* **Management**. Unified management with System Center 2012 R2 gives IT professionals a single pane of glass to manage applications, systems and devices across traditional non-virtualized system, private, hosted and public clouds.
* **Development**. Flexible development allows organization’s developers to use their choice of tools, languages - Microsoft or open source - and open standards to quickly build (parts of) applications and services, connect them with other (parts of) applications, services and data, and then deploy on-premises, in the cloud or in a hybrid model. Visual Studio and Team Foundation Server (TFS) enable application lifecycle management (ALM), from the idea to deployment of an application.



Figure 17. A consistent set of infrastructure that work and extend across public and private clouds

The following sections provide additional details on the above common set of infrastructure that truly represent key enablers for a seamless and smoothly hybrid approach. With such an approach, you don’t indeed need to make a single giant leap to the cloud, but rather you can move at the pace that makes the most sense for your business.

### (Hybrid) Identity

The cloud is changing the way in which applications are written. Accelerated market cycles, multi-tenancy, pure cloud solutions and hybrid deployments, Web programmability and the API economics, the rise of devices (smartphones, tablets, etc.) as well as rich clients as consumption models offer without any doubt new opportunities.

They also present at the same time new challenges for the key services both on-premises and through the (hybrid) cloud that represent the identity lifecycle management, the provisioning, the role management, the authentication with strong identity, and the security for users and devices with granular access.

With:

* The Bring Your Own Apps (BYOA) for cloud and Software as a Service (SaaS) applications,
* The desire to better collaborate a la Facebook with the “social” enterprise,
* The need to support and integrate with social networks, which lead to a Bring Your Own Identity (BYOI) trend,
* Etc.

Identity becomes a service where identity "bridges" in the cloud "talk" to on-premises directories or the directories themselves move and/or are located in the cloud.[[47]](#footnote-48)

Identity, like compute and storage and networking, is an essential platform service. In the same way that identity played a critical role in the adoption of workgroup computing, identity services will play a critical role as organizations adopt the (hybrid) cloud.

Kim Cameron, Microsoft Chief Identity Architect, is convinced[[48]](#footnote-49) that “Organizations will find they need new identity management capabilities to take full advantage of the cloud. They will also find that the most reliable and cost-effect way to obtain these capabilities is through Identity Management as a Service – i.e. using the cloud to master the cloud.

We can therefore predict with certainty that almost all organizations will subscribe to identity services that are cheaper, broader in scope and more capable than the systems of today.

Enterprises will use these services to manage authentication and authorization of internal employees, the supply chain, and customers (including individuals), leads and prospects. Governments will use them when interacting with other government agencies, enterprises and citizens.

Identity Management as a Service will require that we move beyond the models of identity management that have guided our thinking to date. A new service-based model will emerge combining more advanced capabilities with externalization of operations to achieve reduction in risk, effort and cost.”

Active Directory (AD) is a Microsoft brand for identity related capabilities. In the on-premises world, Windows Server Active Directory provides a set of identity capabilities and services and is hugely popular (88% of Fortune 1000 and 95% of enterprises use AD).

With the IaaS capability in the cloud, such as the one offered by the Azure platform, it becomes possible to deploy virtual machines (VM) that host AD domain controller. Whilst such an approach could be more than appropriate for specific workloads on IaaS platforms like a SharePoint environment, the Microsoft vision for the cloud consists in recreating a similar identity service, but one that is optimized to support cloud applications and support modern protocols.

“Azure Active Directory is the world’s largest cloud based, enterprise quality, internet scale Identity and Access Management Solution.  Today over 2.9 million businesses, government bodies and schools are already enjoying the benefits of Azure Active Directory, using it to manage access to Office 365, Dynamics CRM online, Microsoft Intune and Azure.”[[49]](#footnote-50)

[**Azure Active Directory (Azure AD)**](http://azure.microsoft.com/en-us/services/active-directory)[[50]](#footnote-51) is AD reimagined for the cloud[[51]](#footnote-52) [[52]](#footnote-53), designed to solve for you the new identity and access challenges that come with the shift to a cloud-centric, multitenant world.

Azure AD can be truly seen as an Identity Management as a Service (IDaaS) cloud multitenant service that provides a robust and comprehensive cloud identity platform architected to operate in the cloud with high scale, high availability, and integrated disaster recovery. This goes far beyond taking AD and simply running it within a VM in a hosted environment such as the PaaS capability of Azure: Azure AD is definitely different than running AD in an Azure VM.

Azure AD is an enterprise grade, high availability cloud service available for use by organizations who have applications running on any cloud platform or on-premises[[53]](#footnote-54), and is offered as a service on the Azure Cloud platform (see below). Tenants can control the geographical region or regions (US, Europe, Asia, and China) in which their data resides.

Since its introduction, Azure AD "has handled 400 billion identity authentications in Azure AD"[[54]](#footnote-55). "We have 350 million Azure Active Directory users. […] We actually process 18 billion, with a B, authentications every week with Azure Active Directory"[[55]](#footnote-56). This is a real testament to the level of scale we can handle. “At a high level, Azure AD is a high availability, geo-redundant, multi-tenanted, multi-tiered cloud service that has delivered 99.99% uptime for over a year now. We run it across 28[[56]](#footnote-57) datacenters around the world. Azure AD has stateless gateways, front end servers, application servers, and sync servers in all of those data centers. Azure AD also has a distributed data tier that is at the heart of our high availability strategy. Our data tier holds more than 500 million objects and is running across 13 data centers.” [[57]](#footnote-58)

As a cloud based directory, Azure AD makes it easy to:

* Manage user’s access to cloud based LOB applications, Microsoft cloud services such as Office 365, and 3rd party SaaS applications.
* Deliver a Single Sign-On (SSO) experience for cloud applications eliminating the need for multiple usernames and passwords and limiting helpdesk calls and password resets.
* Revoke access to cloud based business applications when an employee leaves the company or changes jobs.
* Manage federation and access to cloud facing services for partners and customers.

For organizations who already run AD on-premises, Azure AD is a natural extension for enabling existing identities in the cloud.  Based on open standards including SAML 2.0, OpenID Connect 1.0, OAuth 2.0, OData 4.0, WS-Federation, WS-Trust, etc. Azure AD works with any modern browsers running on a PC, tablet or mobile device and can be easily integrated into applications running on a multitude of platforms from Microsoft and 3rd parties.

In addition, Azure AD Access Control supports brokering “consumer” identity for your application by simplifying how you work with identity providers like Google, Facebook, LinkedIn, Microsoft Account, etc.

Built on top of a large set of free capabilities in Azure AD, Active Directory Premium provides a robust set of more advanced features to help empower enterprises with more demanding identity and access management needs: company branding, group-based application access, self-service password reset, self-service group management, machine learning based advanced security reports and alerts, multi-factor authentication, grant rights to use a Microsoft Identity Manager (and CALs) in your on-premises network, etc.

### Virtualization

Azure has introduced a complete Infrastructure as a Service (IaaS) solution which enables portability of on-premises virtual machines (VM) to the cloud.

In so far as Azure is based on the same hypervisor technology as Windows Server 2012 R2, e.g. [**Hyper-V**](http://www.microsoft.com/en-us/server-cloud/windows-server/server-virtualization.aspx)[[58]](#footnote-59), IT professionals can easily migrate VMs from on-premises to and run it inside Azure and vice-versa. The mode of transport is the VHD file format – which is a [common virtualization file format common virtualization file format and an open format specification](http://go.microsoft.com/fwlink/p/?linkid=137171)[[59]](#footnote-60) – published by Microsoft and available under the [Microsoft Open Specification Promise (OSP)](http://www.microsoft.com/openspecifications/en/us/programs/osp/default.aspx)[[60]](#footnote-61). (The new [version VHDX](http://www.microsoft.com/en-us/download/details.aspx?id=34750)[[61]](#footnote-62) supported by Windows Server 2012 R2 - also available as a free specification covered under the OSP – will be supported in the future by Azure.

Interestingly enough, the Windows Server 2012 R2 Hyper-V Network Virtualization feature is also available in Azure through the Azure Virtual Networks. This feature delivers network flexibility by enabling multi-tenant virtual networks on a shared physical network, entirely defined in software. Each tenant gets a complete virtual network, including multiple virtual subnets and virtual routing, defined in a ‘policy.’

Such a capability in Azure allows deployment of secure site-to-site connectivity or dedicated private ExpressRoute connections (see later in this paper), as well as protected private virtual networks (VNET) in the cloud. Consequently, it also enables the migration of complete workloads between private and public as the virtualized network configuration is completely decoupled from the underlying physical network configuration.

### Management

[**System Center 2012 R2**](http://www.microsoft.com/en-us/server-cloud/products/system-center-2012-r2)[[62]](#footnote-63) is an integrated management platform that helps organizations confidently consume and deliver hybrid IT as a Service by enabling productive infrastructure, predictable applications, and cloud on your terms.

**Note** For additional information, see the blog post [Transform Your Datacenter with System Center 2012 SP1](http://blogs.technet.com/b/server-cloud/archive/2013/01/15/transform-your-datacenter-with-system-center-2012-sp1.aspx)[[63]](#footnote-64) and the free eBook [Microsoft System Center: Integrated Cloud Platform](http://aka.ms/683143pdf)[[64]](#footnote-65). Organized by cloud type and starting with a short overview of the Cloud OS strategy from Microsoft and a high-level hybrid cloud architecture, the latter covers the design and deployment of private cloud solutions using Windows Server and System Center to deliver the software-defined datacenter where storage, network, compute, and management are all virtualized and delivered by the Microsoft platform

Following System Center 2012 (SP1), System Center 2012 R2 takes another big step forward on delivering the promise of Microsoft’s Cloud OS message:

* **Multi-hypervisor clouds.** Multi-hypervisor clouds enable you to take existing investments in hypervisor technology whether VMWare ESX/vSphere, Citrix XenServer and Windows Server Hyper-V and build them into one consistent fabric, managed as a common cloud infrastructure through the tools in R2. Multi-hypervisor support and other interoperability enhancements in R2 mean that you can begin your journey into the cloud using your existing infrastructure without any need for "rip and replace". From that point it’s really easy to delegate control of portions of this cloud fabric to application owners based on their role, who then allocate resources to their various application workloads.
* **Multi-tenant virtual networks.** System Center supports network virtualization (which is enabled by Windows Server Hyper-V) to abstract workloads from network intricacies while securely isolating multiple tenants/customers. This builds on your existing network investments while enabling pooled, elastic network infrastructure. This sets you up to control virtual network policies centrally in software and link them to your workloads. So when your workload is instantiated or moved, the network configurations adjust themselves automatically (again through the magic of software), thereby removing the need to manually reconfigure your physical network equipment. Finally, to seamlessly move your workloads within and across datacenters and clouds, System Center delivers an in-box software gateway that bridges physical and virtual networks in a flexible manner.

**Note** For additional information, see the free eBook [Microsoft System Center: Building a Virtualized Network Solution](p://aka.ms/683105pdf)[[65]](#footnote-66).This eBook is geared to private and hybrid cloud architects preparing to design and build a virtualized network solution based on Windows Server 2012 and System Center 2012 SP1, or later. It focuses on architecture and design.

* **SAN and file-based storage management.** System Center enables storage management in the context of SANs as well as file-based storage / Storage Spaces, thereby helping you reduce complexity in managing infrastructure while enabling flexibility and choice.

Consistent with the notion of Cloud OS, hybrid is indeed built into the System Center capabilities to truly enable common management that spans Windows Server and Azure environments. Not only is System Center best-of-breed for Windows Server environments and Microsoft key workloads (such as Exchange Server, SharePoint Server and SQL Server) but it also enables robust management of heterogeneous datacenters.

Making it easy to provision, manage, and operate infrastructure services based on Windows Server 2012 R2, System Center provides the following enterprise-grade and ready to use management capabilities:

* **Infrastructure provisioning**. This is about enabling enterprises and service providers to provision an infrastructure that meets their key requirements such as workload scale/performance, heterogeneity, multi-tenancy, and chargeback. System Center can help provision custom or standardized infrastructure for private cloud and public cloud (Azure) environments.
* **Automation and self-service**. System Center gives application owners the agility they need while enabling IT professionals with the tools they need to drive the needed cost-effectiveness and IT control.
* **Infrastructure monitoring**. System Center provides a single toolset to monitor infrastructure resources - physical, virtual, or cloud computing models - across private cloud and public cloud (Azure) environments.
* **Application performance monitoring**. Recognizing that applications are what really matter to the business, System Center provides deep insight necessary to deliver predictable application SLAs to application owners.
* **IT service management**. System Center enables IT professionals to deliver services in a flexible manner by providing the necessary service management processes such as custom service request offerings, process/ knowledge integration, and chargeback.



Figure 18. System Center Helps Deliver IT as a Service

The above System Center components indeed offer the life cycle management capabilities in combination to help you deliver hybrid IT as a Service as per your organization’s requirements, while carrying forward the IT existing datacenter investments and skillsets.

System Center helps IT simplify and standardize the organization’s datacenter with a flexible process automation platform in order to lower operational costs and improve service reliability:

* With **Orchestrator**, IT professionals can integrate and extend the existing IT toolsets and build flexible (runbook) automated workflows that can span across multiple organizational silos and systems. Orchestrator achieves interoperability in this context by installing [Integration Packs](ttp://www.microsoft.com/en-us/download/details.aspx?id=39622)[[66]](#footnote-67), and you make Orchestrator useful by authoring or importing [runbooks](http://technet.microsoft.com/en-us/library/hh403791.aspx). Runbooks call ordered and timed activities such as “read this log” or “run that command”. Orchestrator is aware of these tasks thanks to the imported the integration pack(s). These runbooks are then executed in an orchestrated manner through the automation engine built into Orchestrator.

**Note** For a focused drilldown on designing Orchestrator runbooks for workflow management solutions, see the free eBook [Microsoft System Center: Designing Orchestrator Runbooks](http://aka.ms/682986pdf)[[67]](#footnote-68) that is part of a series of specialized guides on System Center. These titles provide you with concise technical guidance as they step you through key design concepts, criteria, and tasks.(This eBook is accompanied by[companion files](http://aka.ms/682986files)[[68]](#footnote-69).)

Orchestrator also provides Service Provider Foundation (SPF), an extensible OData web service that exposes System Center capabilities as a service.

**Note** For additional information, see the Microsoft TechNet article [Service Provider Foundation](http://technet.microsoft.com/en-us/library/jj642895.aspx)[[69]](#footnote-70).

* **Service Manager** offers industry-standard service management capabilities (based on the Information Technology Infrastructure Library (ITIL) and Microsoft Operations Framework (MOF) proven processes and practices) which automates core IT organizational process workflows like incident management, problem management, change management, and release management.

**Note** For a framework for planning and delivering a successful Service Manager project, see the free eBook [Microsoft System Center: Optimizing Service Manager](http://download.microsoft.com/download/B/4/C/B4CF854B-920F-40BF-823C-9C8C97A42B9C/Microsoft_Press_ebook_SystemCenterOptimizingServiceManager_PDF.pdf)[[70]](#footnote-71) that is part of a series of specialized guides on System Center.These titles provide you with concise technical guidance as they step you through key design concepts, criteria, and tasks. (This eBook is accompanied by[companion files](https://www.microsoftpressstore.com/store/microsoft-system-center-optimizing-service-manager-9780735683129#downloads)[[71]](#footnote-72).)

* With the provisioning capability of **Virtual Machine Manager**, IT professionals can pool and abstract the organization’s datacenter resources (such as compute, network, and storage) into a private cloud infrastructure fabric, which can then be maintained by Virtual Machine Manager and Operations Manager (see below). They can allocate and delegate this pooled fabric to the business unit IT organizations in a flexible, yet controlled, manner using Virtual Machine Manager.

**Note** Microsoft Server Application Virtualization (SAV), a feature of Virtual Machine Manager, optimizes the organization’s applications for private cloud deployments with sequenced state separation between the application and underlying infrastructure. SAV dramatically simplifies application servicing (such as upgrades and maintenance) with image-based configuration and management techniques that reduce administrative effort and expense.

By decoupling the applications from the infrastructure, SAV helps unlock application portability as appropriate to the organization’s business needs. (Configuration Manager supports SAV, thereby extending the benefits of SAV to applications and workloads that may be deployed in traditional non-virtualized environments. Through SAV support, Configuration Manager enables easier physical-to-virtual application mobility and in-place application servicing.)

* Through a unified management console and an automated set of administrative tools to deploy software, protect data, monitor health, and enforce compliance across notably all servers in an organization, **Configuration Manager** helps IT manage the deployed servers, keeping software up-to-date, setting configuration and security policies, and monitoring system status.

**Note** For additional information on how to implement, administer, and troubleshoot software updates using Configuration Manager 2012 R2, see the free eBook [Microsoft System Center Software Update Management Field Experience](http://aka.ms/695849pdf)[[72]](#footnote-73).(This eBook is accompanied by[companion files](http://aka.ms/SUMFE/files)[[73]](#footnote-74).)

**Note** For a focused drilldown on using Configuration Manager for queries and custom reporting, with scenario-based guidance for deployment success, see the free eBook [Microsoft System Center: Configuration Manager Field Experience](http://aka.ms/683044pdf)[[74]](#footnote-75) that is part of a series of specialized guides on System Center.These titles provide you with concise technical guidance as they step you through key design concepts, criteria, and tasks. (This eBook is accompanied by[companion files](http://aka.ms/683044files)[[75]](#footnote-76).)

* **Data Protection Manager** helps IT back up servers, Microsoft workloads, system state, and bare metal recovery (BMR).

**Note** For best practices, design concepts, how-to procedures, and in-depth technical troubleshooting, see the free eBook [Microsoft System Center Data Protection for the Hybrid Cloud](http://aka.ms/Scdatapro_PDF)[[76]](#footnote-77).

Application owners can consume capacity (and request additional capacity) in a self-service mode using the services catalog offered by Service Manager. Requests for capacity would be fulfilled using the process automation and provisioning capabilities offered by Orchestrator and Virtual Machine Manager respectively.

With the ITaaSB model in mind, a service is a deployed instance of an application along with its associated configuration and virtual infrastructure (see section § Towards An Hybrid IT). System Center offers a service-centric approach to help IT manage the various application components in the context of the holistic service that it represents to the business.

From provisioning services (visualization, design, composition, deployment, and configuration) to operating them (monitoring, remediation, and upgrades), the whole platform helps IT manage the full lifecycle. For instance, Virtual Machine Manager and **App Controller** enable service-centric provisioning and updates while Operations Manager enables monitoring at the service level.

**Note** For additional information on core tasks for App Controller to implement and manage hybrid cloud solutions, see the free eBook [Microsoft System Center: Cloud Management with App Controller](http://download.microsoft.com/download/8/6/7/867583B3-EBDE-4932-AC5E-0DCFF75BB382/Microsoft_Press_ebook_SystemCenterCloudMgmtWithAppController_PDF.pdf)[[77]](#footnote-78) that is part of a series of specialized guides on System Center.These titles provide you with concise technical guidance as they step you through key design concepts, criteria, and tasks.

System Center helps IT deliver predictable application service levels with deep application insight, and holistically manage applications and services, which is where the IT core business value resides. For that purposes, **Operations Manager** offers deep application and transaction monitoring insight for .NET applications (and Java EE (Java Platform, Enterprise Edition) application server health) to maximize application availability and performance.

In the today world of modern apps and faster release cycles, Operations Manager also integrates with Visual Studio through a connector to unlock development-to-operations (DevOps) collaboration, thereby helping IT remediate application issues faster, which results in the delivery of predictable SLAs. Easy-to-use reporting and dashboarding allows IT to track and communicate your SLAs more effectively.

**Note** For additional information on the Operations Manager environment and a better understanding of the inner workings of the product, see the free eBook [Microsoft System Center Operations Manager Field Experience](http://aka.ms/695825pdf)[[78]](#footnote-79).

**Note** For additional information on how to extend the reporting capabilities within Operations Manager, see the free eBook [Microsoft System Center Extending Operations Manager Reporting](http://aka.ms/695788/files)[[79]](#footnote-80). (This eBook is accompanied by[companion files](http://aka.ms/695818files)[[80]](#footnote-81).)

As an integrated management solution, System Center helps IT integrate heterogeneous datacenter investments and skillsets through:

* Multi-hypervisor management for Microsoft Hyper-V (see above section), VMware vSphere/ESX, and Citrix XenServer with System Center Virtual Machine Manager.
* Cross-platform monitoring of various distributions such as RHEL/SUSE Linux, Oracle Solaris, HP-UX, and IBM AIX with Operations Manager.
* Cross-platform configuration management for Linux and UNIX servers with Configuration Manager.
* And integrated automation across management toolsets from vendors such as HP, Tivoli, BMC, CA, and VMWare with Orchestrator.

### Application Development

The cloud continues to drive new demands on application development. As illustrated before (see section § Business Reasons for Thinking Hybrid, it enables new ways of conceiving, building and delivering great application experiences for the business in a hybrid manner.

**Note** For additional information, see the blog post [Modern Lifecycle on the Cloud OS](http://blogs.msdn.com/b/bharry/archive/2013/01/15/modern-lifecycle-on-the-cloud-os.aspx)[[81]](#footnote-82).

In addition to identity, virtualization and management, Microsoft provides a common development experience across the on-premises and public cloud including our flagship [**Visual Studio environment**](http://www.visualstudio.com)[[82]](#footnote-83) for .NET platform but also a support for Java with Eclipse, and other open source languages. Azure SDKs are available for .NET, Java, Node.js, PHP, Python, and Ruby.

Visual Studio 2013 provides the most comprehensive solution to easily deliver applications across all Microsoft platforms, including phone, desktop, tablet, server, and the cloud. The Azure Tools for Visual Studio enable you to create, build, debug, run and package scalable web applications and services on Azure from Visual Studio.

In terms of application lifecycle management (ALM) capabilities, Visual Studio 2013 enables you to choose between Team Foundation Server (TFS) for a self-hosted collaboration environment, or Visual Studio Online to manage your software project in the cloud:

* Created to get more out of development teams, [**Team Foundation Server (TFS)**](http://www.visualstudio.com/products/tfs-overview-vs)[[83]](#footnote-84) is the on-premises ALM hub for Visual Studio. It enables all stakeholders to participate in the development process using a single solution to manage the code repositories, build processes, testing infrastructure, and lab deployment all while easily collaborating and reporting status.
* Based on the capabilities of TFS with additional cloud services, [**Visual Studio Online**](http://azure.microsoft.com/en-us/services/visual-studio-online)[[84]](#footnote-85)enables you to get in minutes on our cloud infrastructure an end-to-end, ALM solution accessible from just about anywhere without having to install or configure a single server in your on-premises.

Visual Studio Online handles everything from hosted code repositories and issue tracking to load testing and automated builds to plan, build, and ship software across a variety of platforms. It not only connects to Visual Studio as mentioned above, but also Eclipse, Xcode, and other Git clients to support development for a variety of platforms and languages.

The faster your software is deployed, the quicker you can get feedback. With [release management in Visual Studio](http://www.visualstudio.com/en-us/products/release-management-for-microsoft-visual-studio-vs.aspx)[[85]](#footnote-86), you can configure, approve and deploy your applications for any environment. Release management enables you to create automated deployment orchestrations for each environment no matter how complex the configuration. Delivering your software more frequently and easily to an environment allows your testers to get to work validating your system and keeps your stakeholders involved in giving feedback.

In the next update of release management in Visual Studio, you will be able to directly leverage PowerShell Desired State Configuration (DSC) scripts to configure and manage Windows based environments through release management (see section § Windows Server 2012 R2: The Cloud OS). This extended capability of release management will allow you to manage both on-premises and cloud-based infrastructure as part of an application deployment. This will strengthen the confidence on the configuration of your production environments at the time of a deployment. (see later in this document.)

**Note** For additional information, see the Microsoft TechNet article [Windows PowerShell Desired State Configuration Overview](http://technet.microsoft.com/en-us/library/dn249912.aspx)[[86]](#footnote-87).

## Symmetric Functionalities

### Challenges and Opportunities in the context of Cloud Computing

As previously described (see section § Towards An Hybrid IT), Hybrid IT is the result of combining internal and external services, usually from a combination of private and public clouds, supporting various business outcomes.

When IT organizations investigate potential cloud services, they will find that some public cloud services provide turnkey services that can replace internal software, but they may also be confronted to cloud services that do not meet the compliance policies and/or the risk tolerance for the business. Thus, organizations continue for a while to own and operate internal IT services that house critical applications and data, but there is a good change that these IT services will be (partially or totally) migrated to the public cloud too: the today’s “Core” functions will become tomorrow’s “Context” functions, etc.

**It is primary for this reason why Microsoft introduced the Symmetry strategy.** Indeed, thanks to the fact that all of our products and technologies are built with symmetry in mind, the migration and movement of workloads between on-premises and off-premises (public clouds) and vice-versa are greatly facilitated and don’t necessitate a complex reconsideration of the existing on-premises technological investments and solutions architectures.

For instance, since Azure SQL Database is built with SQL symmetry, any IT service that leverages SQL Server on-premises can smoothly migrate to Azure and Azure SQL Database, and benefits from the public cloud characteristics on-premises at the same time. (More on this later in this document.) Consequently, this symmetry of functionalities and APIs between our public cloud and on-premises products and technologies offers an appropriate response to the portability and reversibility challenges between the on-premises and the public clouds while providing flexibility and choice of deployment.

Moreover, due to the pervasive growth of public clouds, many business units and internal customers have used and grown accustomed to the model of IT as a service, and have consequently defined business processes and budget plans with cloud computing in mind. As of today, it’s more and more common to see these internal customers await from IT organizations to build internal private clouds that not only house critical (LOB) applications, but also provide a self-service, quickly provisioned, show-back-based IT consumption model.

In this context, Microsoft delivers cloud-first services and then provides on-premises products and technologies based on them (Windows Server 2012 R2, Exchange 2013, SharePoint 2013, Azure Services for Windows Server, etc.). **This “cloud-first” paradigm in our products and technologies represents more than an opportunity to bring public cloud capabilities to on-premises environment and thus responding to the aforementioned ITaaSB challenges IT organizations will face.**

The following sections provide additional details about key Microsoft products and technologies in the context of this paper that decline this Symmetry strategy.

### Windows Server 2012 R2: The Cloud OS

[**Windows Server 2012 R2**](http://www.microsoft.com/en-us/server-cloud/products/windows-server-2012-r2)[[87]](#footnote-88) provides the foundation of Microsoft private cloud solutions. As part of the aforementioned “Cloud OS” vision, Windows Server 2012 R2 has been designed based on the Microsoft’s experience in operating world-class datacenters hosting Bing, Xbox Live, Office 365 and Azure.

Indeed, it offers a complete virtualization platform encompassing enhanced server virtualization (VM), but also storage and network virtualization providing a highly available, reliable, consolidated and performing platform on top of which a (multi-tenant) private cloud can be built.

Used in conjunction with System Center 2012 R2, Windows Server 2012 R2 indeed constitutes the cornerstone of a software-defined datacenter.

**Note** For thinking about software-defined datacenters, see the Microsoft Research publication [VL2: A Scalable and Flexible Data Center Network](http://research.microsoft.com/apps/pubs/default.aspx?id=80693)[[88]](#footnote-89).

**Note** For additional information on a variety of aspects that make up the foundation of the software-defined datacenter: virtualization, storage, and networking, see the free eBook [Microsoft System Center Deploying Hyper-V with Software-Defined Storage & Networking](http://aka.ms/695672pdf)[[89]](#footnote-90).By the end, you will have a fully operational, small-scale configuration that will enable you to proceed with evaluation of your own key workloads, experiment with additional features and capabilities, and continue to build your knowledge.

For instance, in terms of **Software Defined Networking (SDN)**, System Center leverages the already introduced Windows Server 2012 R2 Hyper-V Network Virtualization (HNV) to provide additional management capabilities and thus, simplifying the definition and dynamic re-configuration of entire networks. By applying VM placement decisions and the policy updates together, this provides a high degree of agility, automation and centralized control, essential to the smooth operation of a modern datacenter.

**Note** For additional information, see the free eBook [Microsoft System Center: Network Virtualization and Cloud Computing](http://aka.ms/683068pdf)[[90]](#footnote-91).This eBook identifies some key usage and deployment scenarios for cloud computing to provide some deep technical background on the Microsoft SDN solution, enabling you to quickly learn the internals of Hyper-V Network Virtualization (HNV), how it works from end to end, and where and how it should be used.

Moreover, the Windows Server 2012 R2 also introduces the Hyper-V Extensible Switch provides a platform through which Microsoft’s partners can extend SDN policies within the switch. One of the most common use cases for this extensibility is to integrate the virtual switch with the rest of the physical network infrastructure. Interestingly enough, System Center manages Hyper-V switch extensions to ensure that as VMs migrate, their destination host is configured with the required switch extensions.

**Note** For additional information, see the Microsoft TechNet article [Hyper-V Virtual Switch Overview](http://technet.microsoft.com/en-us/library/hh831452.aspx)[[91]](#footnote-92).

System Center further adds management support for isolated tenant networks, IP Virtualization, switch extensions, and logical switch. Such an approach allows partners to enlighten their network software and network equipment to participate in, support, and augment the multi-tenant datacenter brought about by Hyper-V Network Virtualization.

"By enabling network control via software, we give customers the ability to configure and reconfigure their networks to match the changing requirements of their workloads, without compromising multi-tenant isolation and performance that would be expected from traditional networking."[[92]](#footnote-93)

Finally, Windows Server 2012 R2 ships with the PowerShell DSC extension. PowerShell DSC provides a configuration platform built into Windows based on open standards. PowerShell DSC is flexible enough to function reliably and consistently in each stage of the deployment lifecycle (development, test, pre-production, production), as well as during scale-out, which is required in the (hybrid) cloud world.

PowerShell DSC gives you a powerful and easy way to manage your Windows infrastructure, both on-premises and in the cloud. It does this by introducing a very simple declarative syntax into the PowerShell language, and a built-in engine that receives and applies the configuration. You describe the desired state of your environment by using its declarative syntax, and then distribute it to each target node in your environment where it is made so. After the configuration is delivered and applied, it can be used to correct configuration drift when it occurs, or just report on configuration drift, so that you know that it has occurred.

### Azure Pack

[**Azure Pack**](http://www.microsoft.com/en-us/server-cloud/products/windows-azure-pack)[[93]](#footnote-94) is a collection of Azure technologies available at no additional cost that can be seen as an “Azure appliance” for private clouds. As such, it provides a solution to respond to reversibility and portability challenges in the context of cloud computing. This solution, resting on top of Windows Server 2012 R2 and System Center 2012 R2 brings to private clouds Azure capabilities such as web sites, virtual machines, service bus provisioning for queued and topic-based publish/subscribe capabilities, Database-as-a-Service (DBaaS) capabilities for SQL Server and MySQL database servers, management portals for tenants and administrators, and service management and automation APIs.

Just as in Azure, this solution is designed to be fully self-service for end users, for instance allowing organizations to procure and manage their own resources within a framework defined by a hosting provider. In the end, the “cloud experiences” with a private cloud and an Azure subscription (public cloud) are highly symmetric as the capabilities, portals and APIs are the same in these two deployment modes.

The [PowerShell Deployment Toolkit (PDT)](http://gallery.technet.microsoft.com/PowerShell-Deployment-f20bb605)[[94]](#footnote-95) allows you to completely automatically deploy a fully baked System Center 2012 R2 environment with all roles and SQL Servers configured for a running Azure Pack configuration. As good as PDT is, it however leaves quite a few tasks to complete before you have a completely functioning Azure Pack environment. This is where PowerShell DSC comes into play with the Azure Pack for that purpose.

The Azure Pack that leverages parts of System Center 2012 R2 indeed heavily utilizes PowerShell workflows, and it uses Service Management Automation (SMA), which is fundamentally PowerShell behind Azure Pack, to do so.

**Note** For additional information on SMA, see the Microsoft TechNet eponym article [Service Management Automation](http://technet.microsoft.com/en-us/library/dn469260.aspx)[[95]](#footnote-96)andthe free eBook [Microsoft System Center Introduction to Microsoft Automation Solutions](http://aka.ms/695818pdf)[[96]](#footnote-97).The latter explores both SMA and Azure Automation (see later in this document), and how they can be used to meet the automation needs of your Microsoft Azure cloud solutions or your enterprise datacenter environments. (This eBook is accompanied by[companion files](http://aka.ms/695818files)[[97]](#footnote-98).)

PowerShell DSC also enables you to integrate your own PowerShell workflows into SMA.

**Note** While System Center Orchestrator remains a preferred tool for much administrative automation inside the data center, SMA clearly constitutes the new investment area for Microsoft. To evolve beyond a dependency on integration packs as the definition vehicle for workflow tasks, to overcome scaling and multi-tenant limitations, and to provide for effective web-based remote Runbook administration, SMA is indeed the new emerging paradigm for achieving automation in a Microsoft network.

### To benefit from an integrated ready to use solution and rapidly deliver cloud capacity to their users, organizations and service providers can leverage the [**Microsoft Cloud Platform System (CPS)**](http://www.microsoft.com/cps)[[98]](#footnote-99), i.e. an Azure-consistent cloud in a box.

### CPS is a fully integrated and pre-configured system of Microsoft software and Dell hardware, with a Microsoft-led support experience:

* For software, Windows Server 2012 R2, the Azure Pack, and System Center 2012 R2 unsurprisingly make up the core of the system.

### The design and implementation of the software is based on learnings derived while operating the Microsoft Azure public cloud. An orchestrated patching and updating system keeps the both the core Microsoft software as well as firmware up to date so that there is no impact on tenant services, and optimized run-books for multiple Microsoft applications are provided as guidance to enable customers to deploy these applications on CPS.

* For hardware, Dell PowerEdge servers, Dell Storage dense enclosures, and Dell Networking switches make up the core of the rack.

### SQL Server 2014 and Azure SQL Database

**[SQL Server 2014](http://www.microsoft.com/en-us/server-cloud/products/sql-server)**[[99]](#footnote-100) - including SQL Server Integration Services, SQL Server Reporting Services and SQL Server Analysis Services - is the well-known relational database management system and business intelligence platform of Microsoft. Over the years, it has continued to focus on mission critical capabilities and has been recognized as a mission-critical enterprise ready data platform across environments and the cloud with features like:

* Enhanced AlwaysOn SQL Server Failover Cluster Instances (up to 8 secondaries) and Availability Groups that enable to deploy highly available databases.
* Contained Databases that simplify the movement of databases between instances,
* The updateable in-memory column store (enhanced in-memory for data warehousing) and the in-memory engine (codenamed Hekaton) that provide significant performance improvement for existing and new online transactional processing (OLTP) and data-warehouse solutions.

**Note** For additional information, see the free eBook [Introducing Microsoft SQL Server 2014](http://aka.ms/684751pdf)[[100]](#footnote-101).This eBook explains how SQL Server 2014 incorporates the above in-memory technologies to boost performance. It also describes how it eases the transition from on-premises solutions to the cloud with added support for hybrid environments.

SQL Server provides a consistent data platform to run applications on-premises and/or in the cloud with Azure. For legacy applications or for applications that require full SQL Server compatibility, you are able to run a fully compatible version of SQL Server with full feature parity in a Azure Virtual Machine (Azure VM), much like they would in a VM on-premises. Multiple images of SQL Server - including the A8 and A9 compute intensive instance - are thus available in the Azure gallery for SQL Server 2014 as well as the ability to “Bring Your Own License” via license mobility.

**Note** For details about the supported VM instance sizes in Azure, see the article [Sizes for Virtual Machine](https://azure.microsoft.com/documentation/articles/virtual-machines-size-specs)[[101]](#footnote-102).

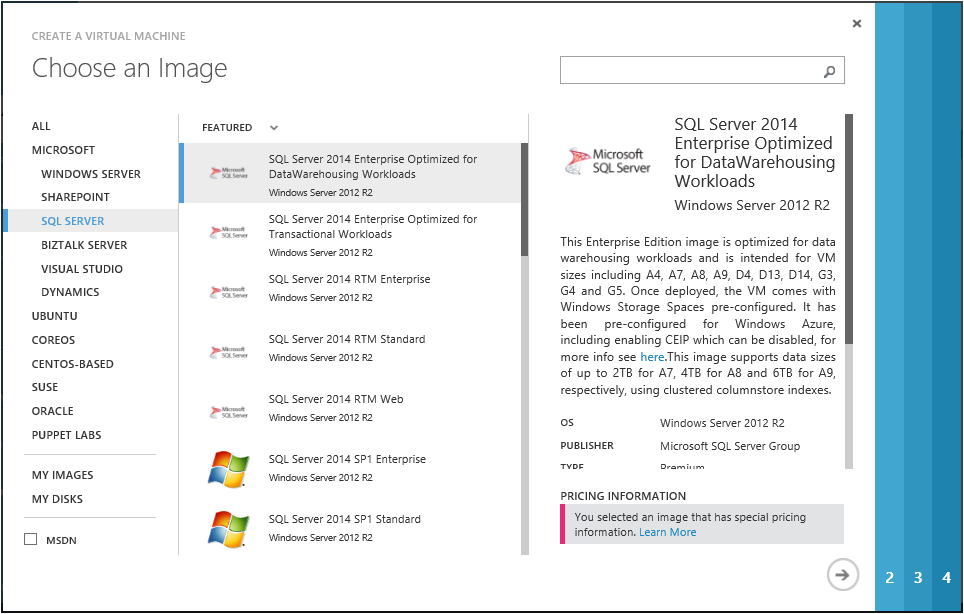


Figure 19. Azure gallery for SQL Server

SQL Server 2014 enables additional hybrid scenarios to enable you to better leverage the benefits and costs of cloud in your environments.

Indeed, beyond the already existing ability to:

* Use the Azure VM to do SQL Server Dev/Test and chose to deploy in production in the cloud or on-premises,
* Use the VM to migrate your on-premises SQL Server to the cloud with many VM sizes to choose from,
* Extend your on-premises applications connecting them to a cloud SQL Server instance using features like linked server in SQL Server and secure site-to-site connection in Azure (see later in this document),

SQL Server 2014 provides the following hybrid capabilities right out of the box:

* **Database backup to Azure**. An optimized, easy to implement, and cost effective backup solution to Azure Storage for on-premises databases to an [**Azure Blob storage**](http://azure.microsoft.com/en-us/services/storage)[[102]](#footnote-103). You can configure it from SQL Server Management Studio, T-SQL, and the PowerShell commandlets.
* **Managed database backup to Azure**. You can set the number of days of backups required and SQL Server will optimize the frequency/volume of backups to Azure to maintain the integrity of the data thanks to an agent that manages and automates the backup policy.
* **Encrypted cloud backup (managed and non-managed)**. Backups are encrypted for greater security in the cloud whilst encryption keys are stored on-premises. This capability supports non-encrypted databases. In other words, you don’t need to turn on Transparent Data Encryption (TDE) to leverage it. Different policies for databases and their backups can be defined to accommodate your requirements.

**Note** A standalone tool enables to support encrypted cloud backups for prior versions of SQL Server.

* **Deploy database to Azure VM wizard**. An easy to use wizard is available for "one click to the cloud" deployment of SQL Server data files in Azure
* **AlwaysOn Replica in Azure**. An easy, cost effective disaster recovery solution that enables you to setup an Azure Virtual Machine as an AlwaysOn secondary for cost effective and low RTO (Recovery Time Objective) DR. The AlwaysOn Availability Groups are supported between Azure regions. The Azure VM secondary can be used for backups and reporting operations.
* **SQL Server data files in Azure**. This capability provides the ability to move both data and log files in Azure storage, while keeping the compute node of SQL Server on-premises. TDE is supported.

SQL Server 2014 is hybrid by design providing a consistent platform on-premises to cloud including development tools with Visual Studio, common virtualization with Windows Server, common management with SQL Server Management Studio and the System Center suite and of course a consistent data platform with SQL Server as the foundation.

**Note** For additional information, see the whitepaper [SQL Server Platform for Hybrid Cloud](http://download.microsoft.com/download/C/1/8/C1834A5C-AAC1-4369-87E0-48DDC2A90608/SQL_Server_Platform_for_Hybrid_Cloud_TDM_White_Paper.pdf)[[103]](#footnote-104).

[**Azure SQL Database**](http://azure.microsoft.com/en-us/services/sql-database)[[104]](#footnote-105) extends the above SQL Server capabilities by providing a multi-tenant relational database service enabling the provisioning of relational databases in the cloud. Benefits notably include manageability, high availability, scalability (through SQL Database Federations), a PAYG economic model as well as a familiar development model and a relational data model.

A Premium offer in market is also available. The Premium provides greater predictable performance for higher transaction volumes with the reservation of dedicated resources for your applications. In addition, the Active Geo-Replication capability allows you to customize the availability of your application to multiple Azure datacenters, and a new Restore Service helps you manage and recover from accidental deletions or changes.

Eventually, [**Azure SQL Data Warehouse**](http://azure.microsoft.com/en-us/services/sql-data-warehouse/)[[105]](#footnote-106), which is based on SQL Server’s proven relational database engine, includes the features you expect in an enterprise data warehouse including stored procedures, user-defined functions, table partitioning, indexes, and collations. Azure SQL Data Warehouse uses the same database engine as SQL Server and Analytics Platform System (APS) (see next section), providing consistency among cloud, on-premises, and appliance solutions, allowing you to choose the best place to keep your data based on performance, security and scale requirements.

### Hadoop on Windows Server and Azure HDInsight Service

With the explosion of data, and thus the broader needs for Big Data - including structured and unstructured data - to better manage and deliver insights, the open source Apache™ Hadoop™ Framework has gaining traction thanks to its huge ecosystem that has arisen around the core functionalities of Hadoop distributed file system (HDFS™) and Hadoop Map Reduce:

* **Hadoop Distributed File System (HDFS™)** stores and replicates blocks of data on the different computers that constitute a Hadoop cluster. The blocks are parts of files.
* **Hadoop Map Reduce** is the framework that implements the Map Reduce algorithm. This algorithm enables highly distributed computing in two main phases based on the usage of keys and values. The map phase transforms key/value input into other key/value outputs. After an intermediary shuffle step that sorts the data by their new keys, the Reduce phase consolidates the values calculated in the first place by the map phase. Several map/reduce jobs can be chained if necessary.

**Microsoft has (developed) a comprehensive Hadoop strategy over across software, appliance, and cloud. The strategy aims at making Hadoop broadly available and accessible across multiple form factors: software, appliance, cloud.**

As one can imagine, it results in various contribution to the Apache Hadoop project[[106]](#footnote-107) by making Hadoop - including a wide range of services such as Pig, Hive and Mahout - equally run on Windows Server and Azure.

Software with [**Hortonworks Data Platform (HDP) for Windows**](http://hortonworks.com/hdp)[[107]](#footnote-108) is developed jointly with Hortonworks. Microsoft doesn’t just resell Hadoop on Hortonworks. Microsoft jointly engineers with them[[108]](#footnote-109). This includes having a joint milestone cadence, a joint roadmap, joint planning and execution, and joint product sign-offs.

At the time of this writing, HDP 2.2 for Windows not only benefits from Hadoop 2.6 the latest version of Hadoop with HDFS and YARN support. YARN is new, general-purpose, distributed, application management framework that has replaced the above classic Apache Hadoop Map Reduce framework for processing data in Hadoop clusters. It effectively serves as the Hadoop operating system, and takes Hadoop from a single-use data platform for batch processing to a multi-use platform that enables batch, interactive, online and stream processing. This new management framework improves scalability and cluster utilization according to criteria such as capacity guarantees, fairness, and service-level agreements

HDP 2.2 for Windows also leverages project Stinger Phase 3 and Tez which aims to bring interactive query to Hadoop. This dramatically improves querying of Hadoop than Map Reduce moving from batch to interactive. It uses a cost based optimizer and a vectorized query engine that came from years of experience from Microsoft’s SQL Server engineering team. With project Stinger Phase 3, Hadoop has a foundational improvement to Hive and querying of data. These Hadoop contributions were completely mainly from collaboration of Microsoft in conjunction with Hortonworks and the community. All told, we’ve contributed 30,000 lines of code and put in 10,000+ engineering hours to support these projects.

Part of the aforementioned Microsoft’s strategy with Hadoop is to make it enterprise ready by integrating with existing IT investments. The Hadoop distribution included in APS has System Center and Active Directory integration making it readily accessible for Microsoft customers.

Microsoft wants to make Hadoop integrate well with existing IT solutions to increase its adoption. This means making Hadoop integrated with System Center for management and Active Directory for security. With System Center integration to Hadoop’s Ambari, a Hadoop cluster can now be managed using Microsoft’s management console. Ambari is an Apache project aimed at making Hadoop management simpler by developing software for provisioning, managing, and monitoring Apache Hadoop clusters. Ambari provides an intuitive, easy-to-use Hadoop management web UI backed by its RESTful APIs.

Appliance investments result in the [**Analytics Platform System (APS)**](http://www.microsoft.com/en-us/server-cloud/products/analytics-platform-system)[[109]](#footnote-110). APS is Microsoft’s high end, tier one appliance. APS provides a single appliance that has both massively parallel processing (MPP), relational data warehouse along with a virtualized Hadoop region in the same appliance.

**Note** In the past, this was named SQL Server Parallel Data Warehouse (PDW). The rebrand showcases that the appliance has been extended beyond core SQL Server data warehousing with 100 percent Apache Hadoop integrated seamlessly into the appliance and thus supports workloads outside of core SQL Server with the opportunity to expand its capabilities in the future.

APS also offers the PolyBase breakthrough data query technology that supports standard SQL queries (T-SQL) for both unstructured and structured data and thus enables you to leverage your existing skills to unlock new insights from unstructured data. As a result, PolyBase provides seamless and unprecedented integration to issue a query that spans both the SQL Server data warehousing and the Hadoop clusters (HDFS). (More on this technology later in this document.)

**Note** The optimization of the query processor automatically converts T-SQL to Map Reduce allowing the execution of Map Reduce directly on the Hadoop cluster and improving the performance of the integrated query between relational and non-relational data residing in Hadoop.

Furthermore, as a result of the aforementioned Microsoft’s strategy with Hadoop to make it enterprise ready by integrating with existing IT investments, the Hadoop distribution included in APS has System Center and Active Directory integration making it readily accessible for Microsoft customers. The System Center integration allows IT professionals to manage both relational and non-relational aspects of the appliance from a single pane of glass whilst the Active Directory integration allows IT professionals to leverage the security that they have already built.

[**Azure HDInsight**](http://azure.microsoft.com/en-us/services/hdinsight)[[110]](#footnote-111) is Microsoft making 100 percent Apache Hadoop-based distribution available over the cloud in Azure. Microsoft leverages the combined work with Hortonworks and then makes this distribution available in the cloud.

Azure HDInsight has recently upgraded to HDP 2.2 (similar to software) and thus leverages the benefits of Hadoop 2.6. With this update to Azure HDInsight, customers can use the speed and scale of the cloud to gain a 100x response time improvement.

**Note** For more information, see the article [What's new in the Hadoop cluster versions provided by HDInsight?](https://azure.microsoft.com/en-us/documentation/articles/hdinsight-component-versioning/)[[111]](#footnote-112).

HBase clusters are also available inside Azure HDInsight. HBase is a NoSQL database component of the Apache Hadoop ecosystem. While relational database management systems typically use rigid tabular schemas, NoSQL databases uses fluid techniques such as key-value, column, graph, or document. They are usually designed for elasticity over large datasets and are less rigorous when it comes to schema. HBase is a columnar NoSQL database that was built to run on top of HDFS. As a low-latency database, it can do OLTP capabilities like updates, inserts, and deletes of data in Hadoop.

This enables customers to run HBase as a managed cluster in the cloud (as an integrated feature of Azure HDInsight). The HBase clusters are configured to store data directly in Azure Blob storage.

This more specifically enables use cases like:

* Building interactive websites that work with large datasets stored in Azure Blobs.
* Building services that store sensor and telemetry data from millions of end points in Azure Blobs (which can then be analyzed using Azure HDInsight (Hadoop).

### Service Bus for Windows Server and Azure Service Bus

[**Azure Service Bus**](http://azure.microsoft.com/en-us/services/service-bus)[[112]](#footnote-113)provides a complete message based infrastructure supporting multiple messaging patterns to connect applications and systems in real-time between Azure and on-premises systems. Messaging provides out-of-the-box support for various messaging patterns that enable to easily connect applications.

[**Service Bus for Windows Server**](http://msdn.microsoft.com/en-us/library/jj193027.aspx)[[113]](#footnote-114) is a set of components that provides the same messaging capabilities of the Azure Service Bus on Windows Server. As such, it enables the building and running of loosely-coupled, message-driven applications and services on-premises while also providing scale and resiliency capabilities. The programming model and APIs exposed by Service Bus for Windows Server are totally symmetric to that of Azure Service Bus, thus making it easier to develop applications and services for either and providing flexibility in the choice of deployment.

The Service Bus provides both relayed and brokered messaging capabilities. In the relayed messaging pattern, the producer and consumer of the messages must be connected at the same time to exchange messages using request/response messaging, one-way messaging or multicast event messaging. Brokered messaging provides durable, asynchronous messaging components such as Queues, Topics and Subscriptions enabled rich publish/subscribe, load leveling and temporal decoupling scenarios: producers and consumers do not have to be online at the same time, the Service Bus infrastructure reliably store messages until the consuming party is ready to receive them.

### BizTalk Server and Azure BizTalk Services

No application is an island. Whether you like it or not, tying systems together has become the norm in today’s world. Yet connecting software is about more than just exchanging bytes. As organizations move toward a service-oriented, API connected world, the real goal - creating effective business processes that unite separate systems into a coherent whole - comes within reach.

[**Microsoft BizTalk Server 2013 R2**](http://www.microsoft.com/en-us/server-cloud/products/biztalk)[[114]](#footnote-115) supports this goal by providing with the tools that you need to connect your Line-Of-Business (LOB) applications across your on-premises, and in the cloud when and where you need them. These tools provide both traditional and new integration capabilities: enterprise application integration (EAI) such ESB (enterprise service bus), Business-to-Business (B2B) integration such as EDI (electronic data interchange), business process management (BPM), data integration, cloud-based integration (CBI), Internet of Things (IoT) supporting capabilities, etc.

With more than 12,000 installed customers, BizTalk Server is the number-one integration solution and value leader worldwide. These customers trust BizTalk for solutions such as payment processing, supply chain management, business-to-business interactions, real-time decision making, and reporting.

To enable powerful hybrid enterprise solutions, BizTalk Server 2013 R2 can integrate with [**Azure BizTalk Services**](http://azure.microsoft.com/en-us/services/biztalk-services)[[115]](#footnote-116), a simple, robust, powerful, and extensible cloud-based integration service.

**Note** Azure BizTalk Services capabilities are now also available in Azure App Service. Azure App Service is a new and unique cloud service that enables developers to create web and mobile apps for any platform and any device. App Service is an integrated solution designed to streamline repeated coding functions, integrate with enterprise and SaaS systems, and automate business processes while meeting your needs for security, reliability, and scalability. For additional information, see the article [What is Azure App Service?](https://azure.microsoft.com/en-us/documentation/articles/app-service-value-prop-what-is/)[[116]](#footnote-117).

Azure BizTalk Services enables powerful business scenarios like supply chain and cloud-based EDI and EAI, all with enterprise grade reliability. It provides built-in support for managing EDI relationships between partners, as well as setting up EAI bridges with on-premises assets - including native support for integrating with on-premises SQL Server, SAP, Oracle EBS, and PeopleSoft. It allows you to connect with any HTTP, FTP, SFTP, or REST data sources. You can then route messages by using various Azure artifacts such as Azure Service Bus queues and topics (see previous section), Azure SQL Database, and Azure Blob storage.

Taking into account the value proposition of both BizTalk Server and Azure BizTalk Services, the integration capabilities between the two, Forrester Research positions Microsoft as a leader in wide integration, deep integration and CBI, and as a strong performer for IoT integration in their study [The Forrester Wave™: Hybrid² Integration, Q1 2014](http://info.windowsazure.com/rs/microsoft/images/Forrester%20Wave_Hybrid%20Integration_Q12014.pdf)[[117]](#footnote-118).

**Note** Forrester’s concept of hybrid integration is defined as federated on-premises and cloud-based integration combined with the improved interoperability of existing and new middleware silos of application, B2B, BPM, business events, business rules, and data integration.

## Hybrid Connectivity Technologies

Various Azure connectivity services enable cross premises connectivity for Hybrid IT in the following areas:

* Data Synchronization.
* Application-layer Connectivity and Messaging.
* Secure Network Connectivity (Site-to-Site, ExpressRoute and Point-to-Site).

### Data Synchronization

The newer **SQL Data Sync** and the **Data Sync Service** are features (in preview as of this writing) of Azure SQL Database that enables synchronization of data between multiple SQL Server and Azure SQL Database instances. This synchronization capability can be seen as a Content Delivery Network (CDN) for structured data, where you can have data across datacenters and regions be synchronized to support rich data-centric applications. The synchronization mechanism is based on “sync groups” which defines the databases, tables, columns and column filters to synchronize data as well as the synchronization schedule, the directionality of the synchronization and the conflict resolution policies. Azure SQL Data Sync is available through the Azure portal and requires the installation of a SQL Azure Data Sync Agent on the SQL Server instances, which are going to be part of a sync group.

**Note** For additional information, see the articles [What's New in SQL Data Sync](https://msdn.microsoft.com/en-us/library/azure/hh456372.aspx)[[118]](#footnote-119) and [Getting Started with Azure SQL Data Sync (Preview)](https://azure.microsoft.com/en-us/documentation/articles/sql-database-get-started-sql-data-sync/)[[119]](#footnote-120).

### Application-layer Connectivity and Messaging

#### Azure Service Bus

As already introduced, Azure Service Bus provides a complete message based infrastructure supporting multiple messaging patterns to connect applications and systems in real-time between Azure and on-premises systems. Messaging provides out-of-the-box support for various messaging patterns that enable to easily connect applications.

Azure Service Bus also supports the OASIS standard Advanced Message Queuing Protocol (AMQP) 1.0 - current version of Windows Server version doesn’t support it at the moment, but we are working on it, thus respecting our Symmetry strategy.

Furthermore, message-oriented middleware (MOM) products and technologies have traditionally implemented and used proprietary protocols for communication between client applications and brokers. This means that, once you’ve selected a particular vendor’s messaging broker, you need to use that vendor’s libraries to connect your client applications and services to it. This results in a degree of lock-in to that vendor, since porting an application or a service to a different product requires re-coding all the connected applications and services. The development of the AMQP standard was primarily motivated by this issue. It originated at JP Morgan Chase, who, like most financial services firms, heavily relies on messages. The goal was (relatively) simple: create an open standard messaging protocol that makes it possible to build message-based applications and services using components built with different languages, frameworks, and operating systems, all using best-of-breed components from a range of suppliers.

#### (BizTalk) Hybrid Connections

**Hybrid Connections** enables cloud services to more securely, quickly, and easily integrate Azure cloud solutions with on-premises Line-Of-Business (LOB) applications.

**Note** For additional information, see the article [Hybrid Connections Overview](https://azure.microsoft.com/en-us/documentation/articles/integration-hybrid-connection-overview/)[[120]](#footnote-121).

With no custom code required, the Hybrid Connections service enables you to connect to any on-premises TCP or HTTP resource - such as Microsoft SQL Server, MySQL, or any HTTP web APIS, and most custom web service - from the [**Web Apps**](http://azure.microsoft.com/en-us/services/app-service/web/)[[121]](#footnote-122)and [**Mobiles Services**](https://azure.microsoft.com/en-us/services/app-service/mobile/)[[122]](#footnote-123), both now part of the aforementioned [**Azure App Service**](https://azure.microsoft.com/en-us/services/app-service/mobile/)[[123]](#footnote-124).

**Note** TCP-based services that use dynamic ports (FTP Passive Mode or Extended Passive Mode) are not supported.

The Hybrid Connections service doesn’t require you to enable a VPN or open up firewall rules in order to use it. This makes it easy to deploy within enterprise environments. Built-in monitoring and management support enables IT professionals control and visibility into the resources accessed by their hybrid LOB applications.

### Secure Network Connectivity

Azure provides networking services and features of interest that will let you design your network topologies with more control and agility.

These capabilities relate to:

* Site-to-Site network connectivity
* Express route connectivity
* and Point-to-Site connectivity

**Note** For information on new capabilities in this space, see the blog post [New Networking Capabilities for a Consistent, Connected and Hybrid Cloud](http://azure.microsoft.com/blog/2015/05/05/new-networking-capabilities-for-a-consistent-connected-and-hybrid-cloud/)[[124]](#footnote-125).

#### Site-to-Site Network Connectivity

[**Azure Virtual Network**](http://azure.microsoft.com/en-us/services/virtual-network)[[125]](#footnote-126) enables to provision and manage virtual private networks (VPNs) in Azure with complete control over network topology as well as securely link these with the on-premises corporate IT infrastructure via an IPsec tunnel(s) (IKE v1 and IKE v2) through the Internet.

With Virtual Network, IT professionals can extend on-premises networks into the cloud with control over network topology, including configuration of DNS and IP address ranges for virtual machines (VM), thus benefiting from a protected private virtual network (VNET) in the cloud.

Not only you can deploy virtual machines (IaaS) inside a virtual network, but you can also deploy your cloud services instances (PaaS) inside a virtual network, thus permitting you to build mixed solutions comprising at the same time IaaS and PaaS building blocks. For instance, one can imagine a solution composed of a SQL Server instance running in a VM (migrated from an on-premises environment) and the front and Web tiers running inside cloud services (and benefiting from the PaaS advantages).

In the above context, Virtual Network supports the use of a hardware VPN device from Cisco, Check Point, Fortinet, Juniper, OpenSwan, SonicWall as well as a pure software based Windows Server 2012 R2 Site-to-Site VPN option,

**Note** Based on a vanilla Windows Server 2012 R2 installation, a simple Windows PowerShell script available from the Azure Management Portal indeed enables the Routing and Remote Access Service (RRAS) on the installation and appropriately configures a Site-To-site VPN tunnel and routing table on it.

Virtual Network supports more than one site-to-site VPN connection so that you can securely connect multiple on-premises locations with VNETs in Azure.

**Note** Virtual Network also supports VNET-to-VNET connectivity. VNET-to-VNET connectivity enables multiple virtual networks to be directly and securely connected with one another. Using this feature, you can connect VNETs that are running in different Azure regions and have traffic route via the Azure backbone. Called cross-region VNET-to-VNET, this feature enables scenarios that require presence in multiple regions, (parts of) applications that are highly available, or the integration of VNETs for a larger network. You can also connect VNETs that are running within the same region (called in-region VNET-to-VNET) for providing additional isolation between (parts of) applications that need to be connected.

#### Point-to-Site Network Connectivity

Beyond the compatibilities outlined in the previous section, Azure Virtual Network also allows to setup VPN connections between individual computers and a VNET without the need for a hardware (or software) VPN device. This Point-to-Site Network Connectivity feature greatly simplifies setting up secure connections between client machines and Azure, whether from your on-premises corporate network or from remote locations.

It is especially useful for developers who want to connect to a VNET (and to the individual virtual machines within it) from either behind their corporate firewall or a remote location. Interestingly enough, IT professionals do not have to perform any activities to enable it, and no VPN hardware needs to be installed or configured. Instead you can just use the built-in Windows VPN client to tunnel to your VNET in Azure. This tunnel uses the Secure Sockets Tunneling Protocol (SSTP) and can automatically traverse firewalls and proxies, while giving you complete security.

#### Private ExpressRoute Network Connectivity

[**Azure ExpressRoute**](http://azure.microsoft.com/en-us/services/expressroute)[[126]](#footnote-127)enables you to create dedicated, private, high-throughput connections between Azure datacenters and your existing infrastructure, whether it’s on-premises or in a colocation environment enabling and simplifying hybrid environments.

**ExpressRoute connections do not go over the public Internet, and they offer more reliability, faster speeds, lower latencies and higher security than typical connections over the Internet.**

With ExpressRoute, you can establish connections to Azure at an ExpressRoute location (Exchange Provider facility) or directly connect to Azure from your existing WAN network (such as a MPLS VPN) provided by a network service provider.

ExpressRoute gives you the ability to use Azure as a natural extension of existing private network or datacenter making it suitable for:

* Implementing storage, backup and recovery in the cloud and thus handling scenarios like periodic data migration, replication for business continuity, disaster recovery and other high availability strategies. It can also be a cost-effective option for transferring large amounts of data such as datasets for high performance computing applications or moving large VMs between your Development/Testing environment in Azure and on-premises production environment.
* Extending the on-premises datacenter (*cloud bursting*) to securely add compute and storage capacity to your existing datacenter whenever needed.
* Building hybrid Line-Of-Business (LOB) applications that span on-premises infrastructure and Azure without compromising security or performance.

# Enabling Common Hybrid Experiences

This section illustrates different common hybrid scenarios that are likely to be very common in the near future with Microsoft cloud offerings and related technologies.

## Hybrid Datacenter

With [**Azure Virtual Machines**](http://azure.microsoft.com/en-us/services/virtual-machines)[[127]](#footnote-128) which are part of Azure Infrastructure Services, you can easily bring your own customized Windows Server or Linux images or select them from a gallery.

This gives you (parts of) application mobility, allowing you to move your virtual hard disks (VHDs) back and forth between on-premises and the cloud (Azure along with hosting service providers).

While “migration” is a simple goal for any IaaS offering, the ultimate objective consists in being able to run the exact same on-premises applications and infrastructure or part of them in the cloud and thus enabling onboarding and off-boarding of workloads in order to improve the agility of the organization, i.e. its ability to capitalize on new opportunities and respond to changes in business demands.

Such a process might involve transferring an entire multi-VM workload, which may require virtual networks for hybrid connectivity to an on-premises deployment. (This can be seen as a cross-premises deployment.) This is where Azure Virtual Networks comes into play.

Azure Virtual Network, another capability of the Azure Infrastructure Services (e.g. IaaS) offering, lets you provision and manage virtual networks (VNET) in Azure. A VNET is the ability for the administrator to create a logical boundary and place into it VMs. VNET also provides the capability of connecting [**Azure Cloud Services**](http://azure.microsoft.com/en-us/services/cloud-services)[[128]](#footnote-129), i.e. web roles and worker roles.

Azure Virtual Network provides control over network topology, including configuration of IP addresses, routing tables and security policies. A VNET has its own private address space. The address space is initially IPv4 only, but could be extended to IPv6 in a future release.

Azure Virtual Network allows securely extending on-premises networks into the cloud. With the ability to assign a private address range for its VNET, an organization can indeed treat it as an extension of its own corporate private network address space by establishing appropriate gates (VPN gateway) between their on-premises corporate private network and their virtual network(s) in Azure.

For that purpose, and as previously outlined, Azure Virtual Network enables to set up secure site-to-site connectivity between the organization’s corporate VPN gateway(s) and Azure, and then to connect the organization’s on-premises corporate network to the organization’s Azure tenant by using VPN gateway(s) along with the industry-standard IPsec protocol.

To go further with additional benefits, Azure Virtual Network also supports ExpressRoute that offers private, predictable, reliable and high-throughput connections from your datacenter to Azure. You can establish the connection at an ExpressRoute location (Exchange Provider facility) or you can directly connect to Azure from your existing WAN network (such as a MPLS VPN) provided by a network service provider.

With such capabilities, IT professionals can easily create a logically isolated private environment in Azure, and connect it to the organization’s on-premises IT infrastructure. Once set up, the isolated Azure environment can be view as a natural extension of the on-premises corporate network.

To synthetize, Azure Virtual Network allows you to create private network(s) of VMs in your Azure tenant(s) environment that you can assign IP addresses to and then connect to your data center through a VPN gateway. Using this method, you can seamlessly connect on-premises (virtual) machines to VMs running in your Azure tenant.

**Note** The [Hybrid Cloud Automation Toolkit - Windows Azure and PowerShell](http://gallery.technet.microsoft.com/Hybrid-Cloud-Automation-02f061a4)[[129]](#footnote-130) provides a collection of example PowerShell scripts that you can leverage to automate the Hybrid Datacenter. For additional information, see the series of blog posts entitled [Automation–Automating Hybrid Clouds with Windows Azure and PowerShell](http://blogs.technet.com/b/privatecloud/archive/2013/11/14/automation-automating-hybrid-clouds-with-windows-azure-and-powershell-part-1-introduction-and-table-of-contents.aspx)[[130]](#footnote-131).

The above capabilities of Azure Infrastructure Services enable the support of four key Microsoft workloads to deploy in the cloud - saving you time and money:

1. **Active Directory**. A hybrid identity solution with extensive networking expectations.
2. **SQL Server**. A database workload with expectations for exceptional disk performance.
3. **BizTalk Server**. A core workload in message-based hybrid solution that leverages Service Bus for Windows Server and Azure Services Bus deployments as transport.
4. **SharePoint Server**. A large-scale, multi-tier application with a load-balanced front-end. Moreover, SharePoint Server deployments include Active Directory and SQL Server.

**Note** For guidance on how to deploy and operate a Microsoft SharePoint 2013 Server farm on Azure Infrastructure Services, see the white paper [SharePoint 2013 on Azure Infrastructure Services](http://www.microsoft.com/en-us/download/details.aspx?id=38428)[[131]](#footnote-132).

As already outlined (see section § Management), System Center truly enables for the hybrid datacenter common management that spans Windows Server and Azure environments. System Center is best-of-breed for the key Microsoft workloads.

Specific Azure features can further sustain the hybrid datacenter like [**Azure Site Recovery**](http://azure.microsoft.com/en-us/services/site-recovery)[[132]](#footnote-133) (formerly known as Hyper-V Recovery Manager). Azure Site Recovery provides a data management, continuity, and disaster recovery (DR) solution which helps protect the availability of System Center private clouds.

This hybrid service uses off-premise automation to control on-premises private clouds that are defined in Virtual Machine Manager to automate the replication of your VMs to Azure, monitors the health of services, provides customizable recovery plans, and orchestrates the recovery of virtual machines in Azure in the event of an outage at the primary site. The service can integrate with PowerShell and the aforementioned DSC can be used to validate DR plans. To perform the replication orchestrated by the service, Virtual Machine Manager notably uses Hyper-V Replica, a replication mechanism built into Hyper-V in Windows Server 2012 R2.

One should also mention [**Azure Automation**](http://azure.microsoft.com/en-us/services/automation)[[133]](#footnote-134) allows you to automate the creation, deployment, monitoring, and maintenance of resources in your Azure environment using a highly scalable and reliable workflow execution engine. Orchestrate time-consuming and frequently repeated tasks across Azure and third-party systems to decrease time to value for your cloud operations.

With Automation, you can connect into any system that exposes an API over typical Internet protocols. Azure Automation ships out of box with integration into many Azure services, including Cloud Services, Azure Virtual Machines and storage.

**Note** For the core concepts around Azure Automation, see the free eBook [Microsoft Azure Essentials: Azure Automation](http://aka.ms/azureautomation_pdf)[[134]](#footnote-135).Using a highly scalable workflow execution environment, Azure Automation allows you to orchestrate frequent deployment and life cycle management tasks using runbooks based on Windows PowerShell Workflow functionality. This eBook is part of the “Microsoft Azure Essentials” series that helps you advance your technical skills with Microsoft Azure.

## Hybrid Cloud Storage

[**StorSimple Hybrid Cloud Storage**](http://www.microsoft.com/en-us/server-cloud/products/storsimple)[[135]](#footnote-136) provides primary storage, backup, archive, and disaster recovery, combined with the Azure environment in the cloud for a seamless integration between your on-premises infrastructure and Azure.

Thanks to a simplified management with automated tiering between StorSimple and Azure, this allows you to optimize total storage costs and increase data protection and service agility. With StorSimple, you can integrate the public cloud with on-premises storage to reduce datacenter infrastructure complexity, maximize data protection, and dramatically reduce overall storage total cost of ownership (TCO), and provision storage more rapidly to reclaim IT time cycles.

File shares and archival with integrated data protection, VM environments, SharePoint environment as well as disaster recovery are typical StorSimple uses cases.

**Note** For additional information, see the free eBook [Rethinking Enterprise Storage: A Hybrid Cloud Model](http://aka.ms/HybridCloudEbook)[[136]](#footnote-137).

As far as backup and recovery are more specifically concerned, one should also mention here [**Azure Backup**](http://azure.microsoft.com/en-us/services/backup)[[137]](#footnote-138). Azure Backups helps protect important server data off-site with automated backup to Azure. It enables you to manage cloud backups from the backup tools you already mastered in Windows Server, Windows Server Essentials, or System Center Data Protection Manager. These tools provide similar experiences configuring, monitoring, and recovering backups whether to local disk or Azure storage. (You can alternatively use the agent software itself.)

Backups are encrypted before transmission and stored encrypted in Azure. These backups are off-site, safely away from your datacenter, protected by reliable Azure storage, reducing the need to secure and protect on-site backup media. After data is backed up to the cloud, authorized users can easily recover backups to any server.

With incremental backups, only changes to files are transferred to the cloud. This helps ensure efficient use of storage and reduced bandwidth consumption, while enabling point-in-time recovery of multiple versions of the data. Configurable data retention policies, data compression, and data transfer throttling offer added flexibility and help boost efficiency.

## Hybrid Line-Of-Business (LOB) Application

As already outlined, Azure is an open and flexible cloud platform that enables you to quickly build using any language, tool or framework, deploy and manage (parts of) applications across a global network of Microsoft-managed datacenters.

Shifting portion(s) of your on-premises applications and services into Azure can be attractive for many reasons, such as:

* Conserving or consolidating capital expenditures into operational expenditures (CAPEX into OPEX).
* Reducing costs (and improving efficiency) by more closely matching demand and capacity.
* Improving agility and time to market by reducing or removing infrastructure barriers, Azure Service Relay being one of the various enablers provided by the Azure environment.
* Increasing audience reach to new markets such as mobile devices thanks to Mobile Services along with Azure Notification Hubs, and/or offering a rich media experiences with Azure Media Services.
* Leveraging the API economics by using other (ecosystem) cloud services (API’s) as building blocks as previously discussed. Azure offers a wide comprehensive portfolio of cloud-based services (API’s) than can serve as building blocks.
* Benefiting from the massive scale of cloud computing by building new applications that can support a global audience in geo-distributed datacenters via intrinsic capabilities such Traffic Manager, Content Delivery Networks (CDN), database synchronization with SQL Data Sync, etc.

As far as the latter is concerned, [**Azure Traffic Manager**](http://azure.microsoft.com/en-us/services/traffic-manager)[[138]](#footnote-139) enables customers to control the distribution of user traffic to specified endpoints, which can be both Azure endpoints (whether they’re located in the same datacenter or across different datacenters around the world) and external endpoints. By effectively managing traffic, one can ensure high performance, availability and resiliency of (parts of) applications than span both Azure, on-premises environments, and even other cloud providers. With support for endpoints that can reside outside of Azure, you can indeed build highly available applications across Azure and your on-premises. In addition, intelligent traffic routing management policies can be applied across all managed endpoints.

CDN improves application performance by caching content at locations closest to your customers. Azure CDN datacenters reduce network latency for customers around the globe. (Azure also offers Azure Caching, a distributed in-memory cache support.)

Globally speaking, there are many excellent technical reasons to develop new applications or port some or all of an existing application to Azure. As the environment is rich with implementation alternatives and API portfolio, one must carefully evaluate the specific application pattern in order to select the correct implementation approach.

Some (parts of) applications are a good fit for Azure Cloud Services (which is a PaaS approach as already mentioned), whilst others might benefit from a partial or complete IaaS approach, such as Azure Virtual Machines. Finally, certain application requirements might be best served by using both together. **Hybrid applications results from a balance among cost, performance,   
time to market and control. Your specific requirements and budget constraints will dictate the solution.**

Considering the above, Azure platform can be easily leverage to build hybrid LOB applications, and consequently to respond to interesting scenarios which are difficult to achieve today in a traditional on-premises environment. In order to name a few, we can mention for instance scalable Web applications that are globally distributed at a world-scale, multi-platform mobile and tablet applications, content delivery and multimedia streaming, B2B collaboration and integration.

The next sections will provide a high-level view and architecture of these aforementioned scenarios. For more information on how to architect and build such hybrid applications on Azure, see the eBook [Building Hybrid Applications in the Cloud on Azure](http://www.microsoft.com/en-us/download/details.aspx?id=30325)[[139]](#footnote-140). This guide focuses on the common issues you will encounter when building applications that run partly in the cloud and partly on-premises, or when you decide to migrate some or all elements of an existing on-premises application to the cloud.

Your design can also benefit from newly introduced services in Azure such as:

* [**Azure API Management**](http://azure.microsoft.com/en-us/services/api-management)[[140]](#footnote-141), which enables you to create and publish an easy to use API façade over a diverse set of backend systems to developers, partners and employees securely and at scale.

These systems could be Azure services (including Web Sites, Mobile Services, VMs, Cloud Services) and/or on-premises existing backend systems that you’d like to ensure internal LOB development teams have access to, some partners have access to, and some third-party external developers have access to. This is notably guided by the proliferation of mobile devices.

There are however several hurdles to providing such a mobile-friendly API (i.e. RESTful API) access, with more specifically publishing challenges (different legacy formats, poor structure, caching, etc.) and management challenges (registration, access control, quotas enforcement, analytics)

Azure API Management addresses each of those challenges by delivering a friendly API developer portal with documentation and samples, enabling per-developer metering support that protects your APIs from abuse and overuse, and enabling to you monitor and track API usage analytics.

Azure API Management helps you enter the API economics so that it’s possible for an organization to monetize its digital assets, transform its product into a platform and create new content distribution channels.

* [**Azure Scheduler**](http://azure.microsoft.com/en-us/services/scheduler)[[141]](#footnote-142), which allows you to invoke actions - such as calling HTTP/S endpoints or posting a message to a storage queue - on any schedule. With Scheduler, you create jobs in the cloud that reliably call services both inside and outside of Azure and run those jobs on demand, on a regularly recurring schedule, or designate them for a future date. This service is currently available as a standalone API.

### Scalable Web-based Application

A scalable web-based application can be useful in many scenarios for organizations, such as an e-Commerce website, a temporary marketing campaign, which will bring millions of visitors to your website on a very short timeframe, a traditional LOB application that needs to be scaled for some reasons, the development of a SaaS offerings to which your customers will subscribe, etc.

Most of the above scenario can leverage the Web Apps. Web Apps is a fully managed PaaS offering part of the Azure App Service that enables you to deploy and scale web-based application in seconds. You can focus on your application code in ASP.NET, Java, PHP, Node.js or Python. Interestingly enough, it enables to run popular web apps and CMS solutions including WordPress, Drupal, Joomla, Umbraco and DotNetNuke. Azure takes care of the infrastructure to scale and securely run it for you.

**Note** For additional information, see the free eBook [Microsoft Azure Essentials Azure Web Apps for Developers](http://aka.ms/AzureWebApps_PDF)[[142]](#footnote-143).This eBook is part of the “Microsoft Azure Essentials” series that helps you advance your technical skills with Microsoft Azure.

To respond to the most more complex scenario, the following architecture can be drawn with the business and front layers of your Web application hosted in Azure inside cloud services (PaaS) and the critical and legacy systems still held on-premises (such as the billing and payment systems for an e-commerce scenario). The communication between the public cloud and the on-premises environments is assured by an Azure Service Bus Queue, thus providing a level of indirection between the two environments, ensuring the reliable storage of messages in the case of a failure or unavailability of some on-premises components.

If the Web application has to be accessed on multiple continents, you can deploy it on multiple Azure datacenters around the world and then leverage the Azure Traffic Manager component mentioned above to adequately redirect customers to the nearest datacenter.



Figure 20. Scalable Web-based application

### Multi-Platform Mobile Application

Building a multi-platform mobile application can be relatively challenging, in so far as it generally requires the development of a common API layer that will be shared by the different client implementations (Android, iOS, Windows Phone 8.x and Windows 8.x).

To accelerate these scenarios, you can leverage Azure App Service - Mobile Services which provide REST APIs that can be consumed by the aforementioned mobile implementations as well as dedicated mobile platform SDKs to accelerate the integration with the REST APIs. The architecture offers similarities with the previous scalable application architecture.



Figure 21. Multi-Platform mobile application

Azure Media Services (see below) integrates with [**Azure Notification Hubs**](http://azure.microsoft.com/en-us/services/notification-hubs)[[143]](#footnote-144), which provides a highly scalable, cross-platform push notification infrastructure that enables you to either broadcast push notifications to millions of users at once or tailor notifications to individual users.

### World-wide Content Delivery and Media Streaming

Azure datacenters, when taken all together, constitute a world-wide distributed architecture, which can be leveraged in order to build CDN at a large scale. As such, you can directly and easily leverage the aforementioned Azure CDN to globally distribute blob files (from the Azure Storage), Azure Data Sync (SDS) service to synchronize relational data between SQL Server and Azure SQL Database instances, and finally the [**Azure Media Services**](http://azure.microsoft.com/en-us/services/media-services)[[144]](#footnote-145) for the media content.

Azure Media Services helps you create end-to-end media workflows with flexible and highly scalable encoding, packaging, and distribution services. Using Azure Media Services, you can securely upload, store, encode and package video or audio content for both on-demand and live streaming delivery to a wide array of TV, PC and mobile device endpoints.



Figure 22. World-wide content delivery and media streaming

### B2B Collaboration and Integration

In today’s world where B2B scenarios are more and more common, there is a good chance that your IT will have to integrate and exchange data with external partnering organizations if it’s not already the case. Whilst it can be potentially challenging particularly from the security perspective, Azure Service Bus provides convenient messaging and security capabilities to deliver messages between organizations, particularly with the Topics and Subscription which provides native message routing and filtering capabilities to dispatch messages across various consumers.



Figure 23. World-wide content delivery and media streaming

As already outlined (see section § BizTalk Server and Azure BizTalk Services), Azure BizTalk Services enables in this context to sustain more advanced business scenarios like supply chain and cloud-based EDI and EAI, all with enterprise grade reliability.

## Hybrid Office Collaboration with Office 365

Office 365 offers many features which can help organizations in deploying a robust hybrid environment that meets its business objectives when it is not possible for an organization to migrate to the cloud immediately or in full due to business, technical, legal or any other reason.

Consequently, the primary targets for an Exchange hybrid deployment based migration to the new Exchange Online are (large) organizations that wish to move mailboxes to Exchange Online over a longer period of time or only want to move a subset of the total mailboxes. For instance, you may be comfortable moving your email to the cloud for your sales staff, but that same choice may not work for your executives who are handling more sensitive information and require greater data privacy. With Office 365, you can do both.

Generally speaking, an Exchange hybrid deployment based migration to the new Exchange Online usually to one of the four following migration approaches:

* Exchange Cutover migrations.
* Staged Exchange migrations.
* Hybrid Exchange Deployment-based migrations.
* IMAP-based e-mail migrations.

The above approaches will differ based on criteria such as size of the on-premises environment, the number of users, the existing messaging environment the organization is migrating from, as well as the expectations revolving around coexistence.

Both Exchange Server 2013 and Office 365 provides number of hybrid deployment improvements.

Considering the various possible options introduced, and for sake of brevity of this paper, please refer to:

* The blog posts [The Cloud On Your Terms (PART I): Deploying Hybrid](http://blogs.technet.com/b/exchange/archive/2012/09/20/the-cloud-on-your-terms-part-i-deploying-hybrid.aspx)[[145]](#footnote-146) and [The Cloud On Your Terms (PART II): Managing Hybrid](http://blogs.technet.com/b/exchange/archive/2012/09/20/the-cloud-on-your-terms-part-ii-managing-hybrid.aspx)[[146]](#footnote-147).
* The Microsoft TechNet article [Exchange Server 2013 Hybrid Deployments](http://technet.microsoft.com/en-us/library/jj200581(v=exchg.150).aspx)[[147]](#footnote-148).

In order to learn about Exchange hybrid scenarios and about how to configure your environment.

Similarly, hybrid SharePoint environments combine on-premises Microsoft SharePoint Server 2013 with Office 365, i.e. Microsoft SharePoint Online. As such, one can configure:

* A one-way hybrid environment that integrates SharePoint Server 2013 and Office 365, which includes the new SharePoint Online, with single sign-on, identity management, and one-way federated search in which Office 365 content appears in on-premises search results.
* A two-way hybrid Search environment that integrates SharePoint Server 2013 and Office 365, which similarly includes the new SharePoint Online, with single sign-on, identity management, and bi-directional federated search.
* A Business Connectivity Services (BCS) hybrid environment.
* Etc.

Organizations can choose how tightly they want to blend their on-premises and cloud environments depending on their appetite for configuring or adding customizations and their long term-plans. Considering the various possible options, and for sake of brevity of this paper, see [SharePoint 2013 hybrid resources](http://www.microsoft.com/en-us/download/details.aspx?id=35593)[[148]](#footnote-149) and the Microsoft TechNet article [Hybrid for SharePoint Server 2013](http://technet.microsoft.com/en-us/library/jj838715(v=office.15).aspx)[[149]](#footnote-150) to learn about SharePoint hybrid scenarios and about how to configure your environment.

This said, we should mention here the new [Cloud App Model in SharePoint](file:///C:\Users\Public\Documents\Activités\DT&S\(Hybrid)%20Cloud\Livrables\FY15\Enabling%20Hybrid%20Cloud%20Today%20with%20Microsoft%20Technologies\:%20http:\blogs.msdn.com\b\officeapps\archive\2012\07\17\introducing-the-new-office-cloud-app-model.aspx)[[150]](#footnote-151) introduced as part of both the SharePoint 2013 and Office 365 releases.  “This new app model for SharePoint is additive to the full trust solutions developers write today, and is built around three core tenants:

* Simplifying the development model and making it consistent between the on-premises version of SharePoint and SharePoint Online provided with Office 365.
* Making the execution model loosely coupled – and enabling developers to build apps and write code that can run outside of the core SharePoint service. This makes it easy to deploy SharePoint apps using Azure, and avoid having to worry about breaking SharePoint and the apps within it when something is upgraded.  This new loosely coupled model also enables developers to write SharePoint applications that can leverage the full capabilities of the .NET Framework – ASP.NET Web Forms 4.5, ASP.NET MVC 4, ASP.NET Web API, EF 5, Async, and more.
* Implementing this loosely coupled model using standard web protocols – like OAuth, JSON, and REST APIs – that enable developers to re-use skills and tools, and easily integrate SharePoint with Web and Mobile application architectures.”[[151]](#footnote-152)

## Hybrid Big Compute

[**Azure Big Compute**](http://azure.microsoft.com/en-us/solutions/big-compute)[[152]](#footnote-153) - more well-known under the name of High Performance Computing (HPC)[[153]](#footnote-154) - is an area in which applications require a lots of computation power provided by supercomputers which typically can run during hours and days or even weeks. These supercomputers were in the past specifically built and designed by companies like Cray or IBM for few high end customers (government labs for instance) and were very expensive. The democratization of commoditized hardware and technologies in the 90’s allowed computers to be connected and managed to easily build computation clusters (known as Beowulf clusters[[154]](#footnote-155)). As a result computation resources and clusters becomes more and more mainstream and provided to a larger scope of customers, opening a new set of applications. These applications covered a vast area of fields like modeling fluid dynamics problems, understanding financial risk analysis, researching disease, transcoding media, simulating weather, etc.

These current in-house on-premises HPC facilities (or HPC private cloud) are unsurprisingly most of the time used at their full capacity in order to maximize their investment. Usually a Job Scheduler application with jobs being queued is the mechanism to keep these systems busy, and managing priority of jobs across different business teams can becomes a complex task. Extending these clusters with new hardware can takes several months and sometimes is even not possible because you run out of physical space or electricity capacity. This is where building a hybrid solution by expanding your system in the cloud can be an interesting offering.

Microsoft have been involved in the HPC landscape since 2006, and the 5th major release of Microsoft HPC product called HPC Pack 2012 R2 has been released in January 2014.

**Note** For additional information, see the Microsoft TechNet article [Microsoft HPC Pack 2012 R2 and HPC Pack 2012](http://technet.microsoft.com/en-us/library/jj899572.aspx)[[155]](#footnote-156).

This free pack is installed on top of Windows Server 2012 R2 and allows customers to seamlessly extend their Windows HPC Cluster to burst on Azure PaaS nodes. A Windows HPC cluster can finally be made by a putting together Windows 7/Windows 8/Windows 8.1 workstations, dedicated and non-dedicated Windows Server 2008 R2, Windows Server 2012 and Windows Server 2012 R2 and Azure nodes.

**Note** For additional information, see the article [Set up a Hybrid Compute Cluster with Microsoft HPC Pack](ttps://azure.microsoft.com/en-us/documentation/articles/cloud-services-setup-hybrid-hpcpack-cluster)[[156]](#footnote-157) as well as the [product documentation](http://technet.microsoft.com/en-us/library/jj899572.aspx)[[157]](#footnote-158).



Figure 24. Windows HPC

One should note that this natural extension while attractive have some restrictions to the nature of workloads and applications that can be executed on hosted on Azure nodes. Traditional HPC environments are built to be dense, connected with fast interconnect technologies such as Infiniband[[158]](#footnote-159) and in which Performance is key with the latest and fastest processors or accelerators.

This at the opposite side from the main design concepts of Azure in which virtualization avoid a direct access to the hardware, in which a deployment is spread across racks to minimize machine downtime, and in which the network infrastructure is not that fast.

Nevertheless, there are some workloads that can easily be run on Azure PaaS nodes in this hybrid mode, which can scale very well and provides obvious benefits. In terms of main characteristics, these workloads are applications:

* That don’t communicate across nodes during computation (like Message Passing Interface (MPI)[[159]](#footnote-160) applications).
* For which the data movement time is less important than the computation time.
* And that can be silently installed.

These applications can be in a non-exhaustive manner:

* In-house financial risk analysis for computing Value at Risk.
* Image rendering, in which each frame to be rendered is independent from others and can takes hours. For instance, a 30mn 3D High Definition movie will require 86400 frames, each frame will require few hours to be rendered on an 8 cores machines.
* Insurance modeling.
* Genome analysis.

These systems can then scale big. To illustrate the point, we have demonstrated in November 2012 that we could scale to 50,000 cores with an Insurance Modeling applications across 6 datacenters. We used 27,000 cores to look for genetic markers.

This is what could be mostly achieved by the end of 2013 based on the previous performance restrictions of Azure.

As introduced in early 2014 with the HPC Pack 2012 R2, Azure now supports the A8 and A9 compute intensive instances along with native Infiniband performance in VMs. They indeed provide the latest high performance CPU technology and ample memory configurations, and connect to a low-latency and high-throughput network in Azure that uses remote direct memory access (RDMA) technology for maximum efficiency of parallel MPI applications. This allows to run compute intensive HPC application in Azure. The performance and scalability of a world-class supercomputing center is now available to everyone, on demand, in a public cloud.

**Note** For additional information about running MPI jobs in your Azure burst deployments, see the article [Run MPI Applications on the A8 and A9 Compute Intensive Instances](https://msdn.microsoft.com/library/azure/dn592104.aspx)[[160]](#footnote-161).

## Hybrid Big Data (and Machine Learning)

Big Data is often defined as data management that requires 3 V: Volume, Variety and Velocity. Volume is the capacity to handle large datasets that don’t fit on one single machine. As a lot of data is kept before being processed, this means that this data may not have a well-known schema at save time; moreover, the schemas at read time may differ between different usages of the same data. Velocity can be the capacity to process large volumes of data in a limited period of time, but it may also be the faculty to transform a big number of signals per seconds in a few functional events per minute. The goal of this is to generate insights from raw data.

As previously mentioned, Microsoft vision and strategy consist in having Hadoop as a natural and seamless complement to the data platform. In order to unlock insights on any data, SQL Server is indeed at the heart of the data platform’s ability to deliver rich insights to users across organizations with high-scale and modern data warehouse capabilities for unstructured and structured data, the ability to combine many types of data internal and external to an organization and the ability to explore and visualize data for insights through rich visualization and BI tools with Excel and the self-service BI in Office 365 (see below).



Figure 25. Microsoft Big Data solutions

Raw data can be sent to StreamInsight for near real time processing. It can also be sent to Azure HDInsight, a 100 percent Apache Hadoop distribution on Azure, HDP on Windows Server, or APS, an appliance that can query data from both non-relational data and traditional relational data in your analysis thru its engine called PolyBase.

While one would normally burden IT to pre-populate the warehouse with Hadoop data or undergo an extensive training on Map Reduce in order to query non-relational data, PolyBase does this all seamlessly giving you the benefits of “Big Data” without the complexities. As already outlined, PolyBase is able to convert T-SQL predicate and aggregates to be pushed into the Hadoop cluster as a Map Reduce job.

Furthermore, in the context of this document, PolyBase allows appliance users to leverage a variety of Azure services to allow APS to better drive hybrid scenarios that bridge on-premises to the cloud. As an example, PolyBase has the ability to reach Azure blobs in Azure HDInsight and thus gives the ability to issue a query that spans on-premises and cloud.

Data that has been structured may then be pushed to the Microsoft data Platform - SQL Server Analysis Services (SSAS), SQL Server Reporting Services (SSRS), etc. - and consumed by end users thru BI tools such as Excel and the self-service BI in Office 365.

By betting on Excel, the power of (big) data insights is brought to the people who are closest to the business – not a specialist with an expensive, specialized tool -- but everyone in the organization can find deeper insights that will help them make better decisions.

A few years ago, Microsoft delivered powerful data modeling and visualization capabilities with Power Pivot and Power View. These tools can create flexible models, process hundreds of millions of rows of data in split second times, and help business users discover and share new insights with colleagues through interactive charts and graphs. To complement these existing Excel capabilities have been introduced Power Query and Power Map.

Power Query helps you to easily discover, access, and combine your data directly through Excel while Power Map allows you to create rich 3D geospatial visualizations in Excel.

This comprehensive set of capabilities in Excel 2013 and Excel in Office 365 ProPlus gives you the ability to do more with your data through quick, easy-to-use, familiar tools. You can indeed search for new data sets both inside and outside their company that can be combined and analyzed within Excel. These new tools not only make it easy to connect to traditional structured data, but also allows you to easily connect to a Hadoop cluster on-premises or to Azure HDInsight in the cloud.

[**Microsoft Power BI**](http://www.microsoft.com/en-us/powerbi)[[161]](#footnote-162) is self-service analytics. It enables to manage larger data volumes, offers premium BI capabilities and connectivity to data inside and outside the organization.

To these extend, it combines the familiarity of the above capabilities in Excel with the ability to host interactive workbooks and data views in Office 365. Additionally, you can share updates with your colleagues in real time and on mobile devices, interact with the data in new ways to gain faster insights and manage your work more effectively.

Power BI includes:

* A Data Management Gateway, which enables IT professionals to build connections to on-premises data sources and schedule refreshes. Business users always have the most up to date reports, whether on their desktop or over their device.
* BI Sites, dedicated workspaces optimized for BI projects, which allow business users to quickly find and share data and reports with colleagues and collaborate over BI results.
* Real-time access to BI Sites and data no matter where a user is located via mobile devices. Customers can access their data through the browser in HTML 5 or through touch-optimized mobile applications for Windows 8.x, Windows RT 8.x, Surface and iPad devices.
* A natural language query experienced called Q&A (available only in English as of this writing) which allows you to ask questions of your data and receive immediate answers in the form of an interactive table, chart or graph.

As its name indicates, all or part of the above hybrid Big Data building blocks can be deployed on-premises or in the cloud in Azure. There are also cases where part of the data comes from the Web, or is generated by many partners that collaborate thru the Internet, and Azure Blob storage may be a rendezvous point for this raw data.



Figure 26. Azure Blob storage as a rendezvous point

Then, it can typically be crunched by one or several Azure HDInsight clusters[[162]](#footnote-163). The data can then be moved from the cloud to the on-premises BI platform where it can be joined to other structured data and consumed by end users.



Figure 27. Data from the cloud back to the on-premises data platform

There are a number of ways to manage this data movement from the cloud to on-premises and vice-versa in cases for instance where data may need to be published to partners thru a DMZ called Azure. This scenario and others are covered in white paper [Leveraging a Hadoop cluster from SQL Server Integration Services (SSIS)](http://msdn.microsoft.com/en-us/library/jj720569.aspx)[[163]](#footnote-164). For the sake of brevity of this paper, these scenarios are not further developed.

Hybrid Big Data where part of the solution leverages the public cloud whilst the rest remains on-premises is a domain where there are many ways to link the two environments seamlessly.

Additionally, the above hybrid Big Data "story" can be extended with Machine Learning in the cloud, thus dramatically simplifying what has traditionally been a complex and costly effort to create end-to-end predictive analytics solutions.

[**Azure Machine Learning (Azure ML)**](http://azure.microsoft.com/en-us/campaigns/machine-learning)[[164]](#footnote-165) is a suite of new offerings designed to democratize the complex task of big data predictive analytics. One Azure subscription is all it takes to build, operationalize, manage and scale an end-to-end predictive analytics solution.

**Note** For additional information, see the free eBook [Microsoft Azure Essentials: Azure Machine Learning](http://aka.ms/AzureML_pdf)[[165]](#footnote-166).This eBook presents an overview of modern data science theory and principles, the associated workflow, and then covers some of the more common machine learning algorithms in use today. It is part of the “Microsoft Azure Essentials” series that helps you advance your technical skills with Microsoft Azure.

The Machine Learning (ML) Studio is a storage account and workspace designed specifically for the data scientist and emerging analytic developer. IT professionals or individual data scientist sets up this ML Studio work and storage space by simply using their Azure subscription and the user is instantly enabled to work with the same best in class algorithms powering Microsoft businesses like Xbox and Bing. Additionally, they can choose to work in their preferred language, such as Python or R. Importing test data into the workspace is as easy as a drop down menu, where you can select cloud storage options such as Azure HDInsight, SQL database, Tables or Blobs. The data scientist can then work independently or with a click share their workspace with anyone across the world, a freedom not offered by today’s restrictive on-premises solutions.

Once the model is complete, the data scientist can easily hand off the model to the IT professional or developer via the Machine Learning (ML) API service, where it can be put into production in minutes and scaled to terabytes of data via Azure HDInsight. Developers and partners can additionally use the ML SDK to build and monetize Machine Learning services on the Azure marketplace. The Line of Business end user can then easily consume the results of the discovery via Excel.

# Conclusion

We’ve covered in this paper the various and different aspects of cloud and more especially private and/or public. We at Microsoft strongly believe that cloud implementations in the future will be hybrid in the cloud continuum if it’s not already the case.

A lot of the security and compliance concerns about the cloud really reflect the public clouds. But the most significant agility, scalability and cost benefits also come from the public cloud. With the private cloud, you retain more control and you have maximum customizability, but you also must purchase and manage the IT infrastructure assets. The hosting service provider are somewhere in between.

In such a foreseeable situation, you should be able to choose how you use the cloud. Depending on what fits your businesses best, you could look at a public solution, or a private solution, or a hosted solution, or - in what we believe will be the most common choice - a bit of both. A hybrid cloud gives you the best way to balance risk and opportunity.

The goal of any hybridization, or combining of two related but dissimilar entities, indeed consist in leveraging the strengths of both parts, while minimizing the components’ weaknesses. As discussed in this paper, hybrid cloud enables organizations to realize a higher degree of flexibility than forcing a choice between either an on-premises or an off-premises cloud-based model (hosting service provider or public cloud). Organizations can start to achieve the benefits associated with the use of cloud computing coupled with the customization, flexibility, and tight data governance of an on-premises IT Infrastructure whilst delivering a consistent experience to businesses and users. Implementing a hybrid cloud solution that combines private, hosting service provider and public cloud services can then greatly help any IT organization achieve important goals such as enhancing its service catalog and making it more flexible and cost-effective.

Microsoft has the resources and knowledge to support any organization’s hybrid cloud ambitions, including the technology to implement a private cloud with on-premises resources along with a broad, comprehensive public cloud offering in IaaS, PaaS, and SaaS.

Microsoft’s hybrid IT indeed offers distinct advantages:

* **Embrace the right IT for your business.** Choice and flexibility are key to cloud adoption now and in the future.Our goal is to help you make the cloud work for your businesses in the context of hybrid IT. It should be up to you to decide what you want to deploy in the cloud and when, so you have the ultimate ability to balance control and flexibility with cost and agility. As illustrated in this paper, Microsoft offers a comprehensive range of enterprise-class cloud offerings that span on-premises and off-premises, helping you move to the cloud at your pace. Do you want better performance, better security, to free up IT staff? We can help you strike the right balance for your businesses by using public cloud(s), hosting service provider(s), private cloud(s), and traditional non-virtualized infrastructure environments that all work together.
* **Make more of your existing IT investments.** It your organization already made a massive investment in IT, taking advantage of the cloud shouldn’t require you to start again. With Microsoft, a hybrid cloud is truly that - it enables you to use your existing IT infrastructure, tools, and skills for maximum value, efficiency, and productivity as you extend to the cloud.
  + Since our platform spans from on-premises to the public cloud, you can use the data center resources that you already have in place to build your own private cloud and then extend into our public cloud.
  + We make the hybrid environment easier on your IT staff by providing a single, unified toolset for managing both traditional and cloud environments.
  + We help you mitigate risk because you can extend Active Directory in your existing environment to the cloud, so you use just one identity infrastructure.
  + And because we provide a common platform that spans from the client to the cloud, we can help you maximize IT and developer productivity.
* **Delight users with the best experiences.** Users have never had higher expectations of the technology they use to do their jobs. As discussed earlier notably with public cloud augmentation, we can help you support today’s workforce with tools that reflect how they prefer to do their work and interact with others. For instance, you can deliver the familiar, business-class experience that your users already love across the PC, tablets, mobile devices, and browser. As another example, no matter where your users are located, you can use the cloud to globally connect them in easy ways.

After reading this paper, we hope that you are now better equipped to embrace with both confidence and efficiency the hybrid cloud and that you now have a better understanding of what the Microsoft’s hybrid IT approach provides and the distinct advantages it offers to enable hybrid cloud today in your organization at your own pace. This concludes this paper.

# References

* Dealing with Darwin (*http://www.dealingwithdarwin.com/theBook/introduction.php*).
* Gartner, Hunting and Harvesting in a Digital World: The 2013 CIO Agenda, January 2013.
* Gartner, 2012 Cloud Computing Planning Guide: From hybrid IT to hybrids Clouds, November 2011.
* Gartner, 2013 Cloud Computing Planning Guide: Rising Expectations, November 2012.
* Gartner, Top 10 Technology Trends, 2013: Cloud Computing and Hybrid IT Drive Future IT Models, February 2013.
* Gartner, 2014 Cloud Computing Planning Guide, October 2013.
* Gartner, 2015 Cloud Computing Planning Guide, October 2014.
* Gartner, Changing Mindets From Applications to Services, December 2012.
* Gartner, Hybrid IaaS, July 2012.
* Gartner, Identity Bridges: Uniting Users and Applications Across the Hybrid Cloud, May 2012.
* Gartner, 2013 Planning Guide: Identity and Privacy, November 2012.
* “NIST Cloud Computing Program,” for the U.S. National Institute of Standards and Technology (NIST) Information Technology Laboratory (ITL) overview of cloud computing, (*http://*[*www.nist.gov/itl/cloud*](http://www.nist.gov/itl/cloud)).
* NIST, SP 800-145, The NIST Definition of Cloud Computing (*http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf*).
* Microsoft Research, VL2: A Scalable and Flexible Data Center Network (*http://research.microsoft.com/apps/pubs/default.aspx?id=80693*).
* “Microsoft Patterns & Practices,” for MSDN patterns and practices, including those for cloud development (*http://msdn.microsoft.com/en-us/library/ff921345.aspx*).
* Microsoft Patterns & Practices Building Hybrid Applications in the Cloud on Azure (*http://msdn.microsoft.com/en-us/library/hh871440.aspx*).
* University of California, Berkeley, Above the Clouds: A Berkeley View of Cloud Computing (*http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.html*).

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1. Introducing Windows Server 2012 R2: http://aka.ms/682788pdf [↑](#footnote-ref-2)
2. Windows Server 2016 Technical Preview 2: https://www.microsoft.com/en-us/evalcenter/evaluate-windows-server-technical-preview [↑](#footnote-ref-3)
3. Introducing Microsoft System Center 2012 R2: http://download.microsoft.com/download/C/8/A/C8A5F520-F31E-4BB4-B972-8D2525D17C38/Microsoft\_Press\_ebook\_Introducing\_System\_Center\_2012\_PDF.pdf [↑](#footnote-ref-4)
4. Microsoft System Center 2016 Technical Preview 2: https://www.microsoft.com/en-us/evalcenter/evaluate-system-center-technical-preview [↑](#footnote-ref-5)
5. Now Available - System Center 2016 Technical Preview 2: http://blogs.technet.com/b/systemcenter/archive/2015/05/06/now-available-system-center-2016-technical-preview-2.aspx [↑](#footnote-ref-6)
6. Above the Clouds: A Berkeley View of Cloud Computing: http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.html [↑](#footnote-ref-7)
7. NIST SP 800-145, The NIST Definition of Cloud Computing: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf [↑](#footnote-ref-8)
8. Ibid [↑](#footnote-ref-9)
9. NIST SP 800-145, The NIST Definition of Cloud Computing: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf [↑](#footnote-ref-10)
10. Ibid [↑](#footnote-ref-11)
11. Ibid [↑](#footnote-ref-12)
12. Ibid [↑](#footnote-ref-13)
13. Gartner, Hunting and Harvesting in a Digital World: The 2013 CIO Agenda, January 2013 [↑](#footnote-ref-14)
14. Dealing with Darwin: http://www.dealingwithdarwin.com/theBook/introduction.php [↑](#footnote-ref-15)
15. KPMG Official: Hybrid Cloud is the Way Ahead for Enterprise: http://www.cio.com/article/710547/KPMG\_Official\_Hybrid\_Cloud\_is\_the\_Way\_Ahead\_for\_Enterprise?taxonomyId=3024 [↑](#footnote-ref-16)
16. Gartner, 2013 Cloud Computing Planning Guide: Rising Expectations, November 2012 [↑](#footnote-ref-17)
17. Why the hybrid cloud model is the best approach: http://www.infoworld.com/d/cloud-computing/why-the-hybrid-cloud-model-the-best-approach-477 [↑](#footnote-ref-18)
18. Gartner, Top 10 Technology Trends, 2013: Cloud Computing and Hybrid IT Drive Future IT Models, February 2013 [↑](#footnote-ref-19)
19. Gartner, Changing Mindets From Applications to Services, December 2012 [↑](#footnote-ref-20)
20. Cloud Security Alliance: https://cloudsecurityalliance.org/ [↑](#footnote-ref-21)
21. Cloud Controls Matrix v3.0: https://cloudsecurityalliance.org/download/cloud-controls-matrix-v3 [↑](#footnote-ref-22)
22. Security Guidance for Critical Areas of Focus in Cloud Computing V3.0: https://cloudsecurityalliance.org/download/security-guidance-for-critical-areas-of-focus-in-cloud-computing-v3/ [↑](#footnote-ref-23)
23. Gartner, 2013 Cloud Computing Planning Guide: Rising Expectations, November 2012 [↑](#footnote-ref-24)
24. Gartner, 2012 Cloud Computing Planning Guide: From hybrid IT to hybrids Clouds, November 2011 [↑](#footnote-ref-25)
25. Gartner, ILM: The Art of Data Placement, December 2009 [↑](#footnote-ref-26)
26. Gartner, Identity Bridges: Uniting Users and Applications Across the Hybrid Cloud, May 2012 [↑](#footnote-ref-27)
27. Gartner, 2013 Planning Guide: Identity and Privacy, November 2012 [↑](#footnote-ref-28)
28. Cloud OS Vision: http://www.microsoft.com/en-us/server-cloud/cloud-os/default.aspx [↑](#footnote-ref-29)
29. Microsoft Global Foundation Services (GFS): http://www.globalfoundationservices.com [↑](#footnote-ref-30)
30. What is the Cloud OS?: http://blogs.technet.com/b/microsoft\_blog/archive/2013/01/15/what-is-the-cloud-os.aspx [↑](#footnote-ref-31)
31. Microsoft Azure: http://www.microsoft.com/azure [↑](#footnote-ref-32)
32. Microsoft Azure infographic: http://azure.microsoft.com/en-us/documentation/infographics/azure/ [↑](#footnote-ref-33)
33. Microsoft Azure Essentials: Fundamentals of Azure: http://aka.ms/697225pdf [↑](#footnote-ref-34)
34. Microsoft Office 365: http://www.microsoft.com/office365 [↑](#footnote-ref-35)
35. Microsoft private cloud solutions: http://www.microsoft.com/privatecloud [↑](#footnote-ref-36)
36. Microsoft Private Cloud – Making It Real: http://download.microsoft.com/download/1/0/7/107D3951-9732-421D-8B57-AC19530F24D1/Private%20Cloud%20Making%20It%20Real.pdf [↑](#footnote-ref-37)
37. What is the Cloud OS?: http://blogs.technet.com/b/microsoft\_blog/archive/2013/01/15/what-is-the-cloud-os.aspx [↑](#footnote-ref-38)
38. Ibid [↑](#footnote-ref-39)
39. Microsoft Build 2015 conference: http://channel9.msdn.com/events/build/2015 [↑](#footnote-ref-40)
40. Microsoft Ignite 2015 conference: http://channel9.msdn.com/events/ignite/2015 [↑](#footnote-ref-41)
41. Announcing the Microsoft Azure Stack: http://blogs.technet.com/b/server-cloud/archive/2015/05/04/announcing-microsoft-azure-stack.aspx [↑](#footnote-ref-42)
42. Bring the power of Microsoft Azure to your datacenter: http://www.microsoft.com/en-us/server-cloud/products/azure-in-your-datacenter/ [↑](#footnote-ref-43)
43. Announcing Azure Service Fabric: Reducing Complexity in a Hyper-scale World: http://azure.microsoft.com/blog/2015/04/20/announcing-azure-service-fabric-reducing-complexity-in-a-hyper-scale-world/ [↑](#footnote-ref-44)
44. Azure Service Fabric: http://azure.microsoft.com/en-us/campaigns/service-fabric/ [↑](#footnote-ref-45)
45. Azure Service Fabric documentation (preview): http://azure.microsoft.com/en-us/documentation/services/service-fabric/ [↑](#footnote-ref-46)
46. Microsoft and Service Providers Deliver on the Cloud OS Vision Together: http://blogs.technet.com/b/hosting/archive/2013/01/15/microsoft-and-service-providers-deliver-on-the-cloud-os-vision-together.aspx [↑](#footnote-ref-47)
47. Gartner, 2013 Planning Guide: Identity and Privacy, November 2012 [↑](#footnote-ref-48)
48. Identity Management as a Service: http://www.identityblog.com/?p=1205 [↑](#footnote-ref-49)
49. Azure Active Directory: Ready for Production with over 265 Billion Authentications & 2.9 Million Organizations Served!: http://blogs.msdn.com/b/windowsazure/archive/2013/04/08/windows-azure-active-directory-ready-for-production-with-over-265-billion-authentications-amp-2-5-million-organizations-served.aspx [↑](#footnote-ref-50)
50. Azure Active Directory: http://azure.microsoft.com/en-us/services/active-directory [↑](#footnote-ref-51)
51. Reimaging Active Directory for the Social Enterprise (Part 1): http://blogs.msdn.com/b/windowsazure/archive/2012/05/23/reimagining-active-directory-for-the-social-enterprise-part-1.aspx [↑](#footnote-ref-52)
52. Reimaging Active Directory for the Social Enterprise (Part 2): http://blogs.msdn.com/b/windowsazure/archive/2012/06/20/reimagining-active-directory-for-the-social-enterprise-part-2.aspx [↑](#footnote-ref-53)
53. Windows Azure Active Directory: Ready for Production with over 265 Billion Authentications & 2.9 Million Organizations Served!: http://blogs.msdn.com/b/windowsazure/archive/2013/04/08/windows-azure-active-directory-ready-for-production-with-over-265-billion-authentications-amp-2-5-million-organizations-served.aspx [↑](#footnote-ref-54)
54. Microsoft by the Numbers: The Enterprise Cloud (October 2014): http://news.microsoft.com/cloud/ms\_numbers.pdf [↑](#footnote-ref-55)
55. Jason Zander and Joe Belfiore: TechEd Europe 2014: http://news.microsoft.com/speeches/jason-zander-and-joe-belfiore-teched-europe-2014/ [↑](#footnote-ref-56)
56. Azure AD is live in Hong Kong!: http://blogs.technet.com/b/ad/archive/2014/10/06/azure-ad-now-live-in-hong-kong.aspx [↑](#footnote-ref-57)
57. Azure AD: Under the hood of our geo-redundant, highly available, distributed cloud directory: http://blogs.technet.com/b/ad/archive/2014/09/02/azure-ad-under-the-hood-of-our-geo-redundant-highly-available-geo-distributed-cloud-directory.aspx [↑](#footnote-ref-58)
58. Virtualization: http://www.microsoft.com/en-us/server-cloud/windows-server/server-virtualization.aspx [↑](#footnote-ref-59)
59. Virtual Hard Disk Image Format Specification: http://go.microsoft.com/fwlink/p/?linkid=137171 [↑](#footnote-ref-60)
60. Open Specification Promise: http://www.microsoft.com/openspecifications/en/us/programs/osp/default.aspx [↑](#footnote-ref-61)
61. VHDX Format Specification v1.00: http://www.microsoft.com/en-us/download/details.aspx?id=34750 [↑](#footnote-ref-62)
62. System Center 2012 R2: http://www.microsoft.com/en-us/server-cloud/products/system-center-2012-r2 [↑](#footnote-ref-63)
63. Transform Your Datacenter with System Center 2012 SP1: http://blogs.technet.com/b/server-cloud/archive/2013/01/15/transform-your-datacenter-with-system-center-2012-sp1.aspx [↑](#footnote-ref-64)
64. Microsoft System Center: Integrated Cloud Platform: http://aka.ms/683143pdf [↑](#footnote-ref-65)
65. Microsoft System Center: Building a Virtualized Network Solution: p://aka.ms/683105pdf [↑](#footnote-ref-66)
66. System Center 2012 R2 - Orchestrator Component Add-ons and Extensions: http://www.microsoft.com/en-us/download/details.aspx?id=39622 [↑](#footnote-ref-67)
67. Microsoft System Center: Designing Orchestrator Runbooks: http://aka.ms/682986pdf [↑](#footnote-ref-68)
68. Companion files: http://aka.ms/682986files [↑](#footnote-ref-69)
69. Service Provider Foundation: http://technet.microsoft.com/en-us/library/jj642895.aspx [↑](#footnote-ref-70)
70. Microsoft System Center: Optimizing Service Manager: http://download.microsoft.com/download/B/4/C/B4CF854B-920F-40BF-823C-9C8C97A42B9C/Microsoft\_Press\_ebook\_SystemCenterOptimizingServiceManager\_PDF.pdf [↑](#footnote-ref-71)
71. Companion files: https://www.microsoftpressstore.com/store/microsoft-system-center-optimizing-service-manager-9780735683129#downloads [↑](#footnote-ref-72)
72. Microsoft System Center Software Update Management Field Experience: http://aka.ms/695849pdf [↑](#footnote-ref-73)
73. Companion files: http://aka.ms/SUMFE/files [↑](#footnote-ref-74)
74. Microsoft System Center: Configuration Manager Field Experience: http://aka.ms/683044pdf [↑](#footnote-ref-75)
75. Companion files: http://aka.ms/683044files [↑](#footnote-ref-76)
76. Microsoft System Center Data Protection for the Hybrid Cloud: http://aka.ms/Scdatapro\_PDF [↑](#footnote-ref-77)
77. Microsoft System Center: Cloud Management with App Controller: http://download.microsoft.com/download/8/6/7/867583B3-EBDE-4932-AC5E-0DCFF75BB382/Microsoft\_Press\_ebook\_SystemCenterCloudMgmtWithAppController\_PDF.pdf [↑](#footnote-ref-78)
78. Microsoft System Center Operations Manager Field Experience: http://aka.ms/695825pdf [↑](#footnote-ref-79)
79. Microsoft System Center Extending Operations Manager Reporting: http://aka.ms/695788pdf [↑](#footnote-ref-80)
80. Companion files: http://aka.ms/695788/files [↑](#footnote-ref-81)
81. Modern Lifecycle on the Cloud OS: http://blogs.msdn.com/b/bharry/archive/2013/01/15/modern-lifecycle-on-the-cloud-os.aspx [↑](#footnote-ref-82)
82. Visual Studio environment: http://www.visualstudio.com [↑](#footnote-ref-83)
83. Team Foundation Server: http://www.visualstudio.com/products/tfs-overview-vs [↑](#footnote-ref-84)
84. Visual Studio Online: http://azure.microsoft.com/en-us/services/visual-studio-online [↑](#footnote-ref-85)
85. Release Management for Visual Studio: http://www.visualstudio.com/en-us/products/release-management-for-microsoft-visual-studio-vs.aspx [↑](#footnote-ref-86)
86. Windows PowerShell Desired State Configuration Overview: http://technet.microsoft.com/en-us/library/dn249912.aspx [↑](#footnote-ref-87)
87. Windows Server 2012 R2: http://www.microsoft.com/en-us/server-cloud/products/windows-server-2012-r2 [↑](#footnote-ref-88)
88. VL2: A Scalable and Flexible Data Center Network: http://research.microsoft.com/apps/pubs/default.aspx?id=80693 [↑](#footnote-ref-89)
89. Microsoft System Center Deploying Hyper-V with Software-Defined Storage & Networking: http://aka.ms/695672pdf [↑](#footnote-ref-90)
90. Microsoft System Center: Network Virtualization and Cloud Computing: http://aka.ms/683068pdf [↑](#footnote-ref-91)
91. Hyper-V Virtual Switch Overview: http://technet.microsoft.com/en-us/library/hh831452.aspx [↑](#footnote-ref-92)
92. Software Defined Networking, Enabled in Windows Server 2012 and System Center 2012 SP1, Virtual Machine Manager: http://blogs.technet.com/b/windowsserver/archive/2012/08/22/software-defined-networking-enabled-in-windows-server-2012-and-system-center-2012-sp1-virtual-machine-manager.aspx [↑](#footnote-ref-93)
93. Azure Pack: http://www.microsoft.com/en-us/server-cloud/products/windows-azure-pack [↑](#footnote-ref-94)
94. PowerShell Deployment Toolkit: http://gallery.technet.microsoft.com/PowerShell-Deployment-f20bb605 [↑](#footnote-ref-95)
95. Service Management Automation: http://technet.microsoft.com/en-us/library/dn469260.aspx [↑](#footnote-ref-96)
96. Microsoft System Center Introduction to Microsoft Automation Solutions: http://aka.ms/695818pdf [↑](#footnote-ref-97)
97. Companion files: http://aka.ms/695818files [↑](#footnote-ref-98)
98. Microsoft Cloud Platform System: http://www.microsoft.com/cps [↑](#footnote-ref-99)
99. Microsoft SQL Server 2014: http://www.microsoft.com/en-us/server-cloud/products/sql-server [↑](#footnote-ref-100)
100. Introducing Microsoft SQL Server 2014: http://aka.ms/684751pdf [↑](#footnote-ref-101)
101. Sizes for Virtual Machine: https://azure.microsoft.com/documentation/articles/virtual-machines-size-specs [↑](#footnote-ref-102)
102. Azure Storage: http://azure.microsoft.com/en-us/services/storage [↑](#footnote-ref-103)
103. SQL Server Platform for Hybrid Cloud: http://download.microsoft.com/download/C/1/8/C1834A5C-AAC1-4369-87E0-48DDC2A90608/SQL\_Server\_Platform\_for\_Hybrid\_Cloud\_TDM\_White\_Paper.pdf [↑](#footnote-ref-104)
104. Azure SQL Database: http://azure.microsoft.com/en-us/services/sql-database [↑](#footnote-ref-105)
105. Azure SQL Data Warehouse: http://azure.microsoft.com/en-us/services/sql-data-warehouse/ [↑](#footnote-ref-106)
106. See https://issues.apache.org/jira/browse/HADOOP-8079 [↑](#footnote-ref-107)
107. Hortonworks Data Platform (HDP) for Windows: http://hortonworks.com/hdp [↑](#footnote-ref-108)
108. Hortonworks & Microsoft: Bringing Apache Hadoop to Windows: http://hortonworks.com/partner/microsoft/ [↑](#footnote-ref-109)
109. Analytics Platform System (APS): http://www.microsoft.com/en-us/server-cloud/products/analytics-platform-system [↑](#footnote-ref-110)
110. Azure HDInsight: http://azure.microsoft.com/en-us/services/hdinsight [↑](#footnote-ref-111)
111. What's new in the Hadoop cluster versions provided by HDInsight?: https://azure.microsoft.com/en-us/documentation/articles/hdinsight-component-versioning/ [↑](#footnote-ref-112)
112. Azure Service Bus: http://azure.microsoft.com/en-us/services/service-bus [↑](#footnote-ref-113)
113. Service Bus for Windows Server: http://msdn.microsoft.com/en-us/library/jj193027.aspx [↑](#footnote-ref-114)
114. Microsoft BizTalk Server 2013 R2: http://www.microsoft.com/en-us/server-cloud/products/biztalk [↑](#footnote-ref-115)
115. Azure BizTalk Services: http://azure.microsoft.com/en-us/services/biztalk-services [↑](#footnote-ref-116)
116. What is Azure App Service?: https://azure.microsoft.com/en-us/documentation/articles/app-service-value-prop-what-is/ [↑](#footnote-ref-117)
117. The Forrester Wave™: Hybrid² Integration, Q1 2014: http://info.windowsazure.com/rs/microsoft/images/Forrester%20Wave\_Hybrid%20Integration\_Q12014.pdf [↑](#footnote-ref-118)
118. What's New in SQL Data Sync: https://msdn.microsoft.com/en-us/library/azure/hh456372.aspx [↑](#footnote-ref-119)
119. Getting Started with Azure SQL Data Sync (Preview): https://azure.microsoft.com/en-us/documentation/articles/sql-database-get-started-sql-data-sync/ [↑](#footnote-ref-120)
120. Hybrid Connections Overview: https://azure.microsoft.com/en-us/documentation/articles/integration-hybrid-connection-overview/ [↑](#footnote-ref-121)
121. Web Apps: http://azure.microsoft.com/en-us/services/app-service/web/ [↑](#footnote-ref-122)
122. Mobiles Services: https://azure.microsoft.com/en-us/services/app-service/mobile/ [↑](#footnote-ref-123)
123. Azure App Service: https://azure.microsoft.com/en-us/services/app-service/ [↑](#footnote-ref-124)
124. New Networking Capabilities for a Consistent, Connected and Hybrid Cloud: http://azure.microsoft.com/blog/2015/05/05/new-networking-capabilities-for-a-consistent-connected-and-hybrid-cloud/ [↑](#footnote-ref-125)
125. Azure Virtual Network: http://azure.microsoft.com/en-us/services/virtual-network [↑](#footnote-ref-126)
126. Azure ExpressRoute: http://azure.microsoft.com/en-us/services/expressroute [↑](#footnote-ref-127)
127. Azure Virtual Machines: http://azure.microsoft.com/en-us/services/virtual-machines [↑](#footnote-ref-128)
128. Azure Cloud Services: http://azure.microsoft.com/en-us/services/cloud-services [↑](#footnote-ref-129)
129. Hybrid Cloud Automation Toolkit - Windows Azure and PowerShell: http://gallery.technet.microsoft.com/Hybrid-Cloud-Automation-02f061a4 [↑](#footnote-ref-130)
130. Automation–Automating Hybrid Clouds with Windows Azure and PowerShell (Part 1): Introduction and Table of Contents: http://blogs.technet.com/b/privatecloud/archive/2013/11/14/automation-automating-hybrid-clouds-with-windows-azure-and-powershell-part-1-introduction-and-table-of-contents.aspx [↑](#footnote-ref-131)
131. SharePoint 2013 on Azure Infrastructure Services: http://www.microsoft.com/en-us/download/details.aspx?id=38428 [↑](#footnote-ref-132)
132. Azure Site Recovery: http://azure.microsoft.com/en-us/services/site-recovery [↑](#footnote-ref-133)
133. Azure Automation: http://azure.microsoft.com/en-us/services/automation [↑](#footnote-ref-134)
134. Microsoft Azure Essentials: Azure Automation: http://aka.ms/azureautomation\_pdf [↑](#footnote-ref-135)
135. StorSimple Hybrid Cloud Storage: http://www.microsoft.com/en-us/server-cloud/products/storsimple [↑](#footnote-ref-136)
136. Rethinking Enterprise Storage: A Hybrid Cloud Model: http://aka.ms/HybridCloudEbook [↑](#footnote-ref-137)
137. Azure Backup: http://azure.microsoft.com/en-us/services/backup [↑](#footnote-ref-138)
138. Azure Traffic Manager: http://azure.microsoft.com/en-us/services/traffic-manager [↑](#footnote-ref-139)
139. Building Hybrid Applications in the Cloud on Azure: http://www.microsoft.com/en-us/download/details.aspx?id=30325 [↑](#footnote-ref-140)
140. Azure API Management: http://azure.microsoft.com/en-us/services/api-management [↑](#footnote-ref-141)
141. Azure Scheduler: http://azure.microsoft.com/en-us/services/scheduler [↑](#footnote-ref-142)
142. Microsoft Azure Essentials Azure Web Apps for Developers: http://aka.ms/AzureWebApps\_PDF [↑](#footnote-ref-143)
143. Azure Notification Hubs: http://azure.microsoft.com/en-us/services/notification-hubs [↑](#footnote-ref-144)
144. Azure Media Services: http://azure.microsoft.com/en-us/services/media-services [↑](#footnote-ref-145)
145. The Cloud On Your Terms (PART I): Deploying Hybrid: http://blogs.technet.com/b/exchange/archive/2012/09/20/the-cloud-on-your-terms-part-i-deploying-hybrid.aspx [↑](#footnote-ref-146)
146. The Cloud On Your Terms (PART II): Managing Hybrid: http://blogs.technet.com/b/exchange/archive/2012/09/20/the-cloud-on-your-terms-part-ii-managing-hybrid.aspx [↑](#footnote-ref-147)
147. Exchange Server 2013 Hybrid Deployments: http://technet.microsoft.com/en-us/library/jj200581(v=exchg.150).aspx [↑](#footnote-ref-148)
148. SharePoint 2013 hybrid resources: http://www.microsoft.com/en-us/download/details.aspx?id=35593 [↑](#footnote-ref-149)
149. Hybrid for SharePoint Server 2013: http://technet.microsoft.com/en-us/library/jj838715(v=office.15).aspx [↑](#footnote-ref-150)
150. Introducing the new Office cloud app model: http://blogs.msdn.com/b/officeapps/archive/2012/07/17/introducing-the-new-office-cloud-app-model.aspx [↑](#footnote-ref-151)
151. SharePoint Apps and Azure: http://weblogs.asp.net/scottgu/archive/2012/11/18/sharepoint-apps-and-windows-azure.aspx [↑](#footnote-ref-152)
152. Azure Big Compute: http://azure.microsoft.com/en-us/solutions/big-compute [↑](#footnote-ref-153)
153. See “Supercomputer” on Wikipedia: http://en.wikipedia.org/wiki/Supercomputer [↑](#footnote-ref-154)
154. See “Beowulf cluster” on Wikipedia: http://en.wikipedia.org/wiki/Beowolf\_cluster [↑](#footnote-ref-155)
155. Microsoft HPC Pack 2012 R2 and HPC Pack 2012: http://technet.microsoft.com/en-us/library/jj899572.aspx [↑](#footnote-ref-156)
156. Set up a Hybrid Compute Cluster with Microsoft HPC Pack: https://azure.microsoft.com/en-us/documentation/articles/cloud-services-setup-hybrid-hpcpack-cluster/ [↑](#footnote-ref-157)
157. Microsoft HPC Pack 2012 R2 and HPC Pack 2012: http://technet.microsoft.com/en-us/library/jj899572.aspx [↑](#footnote-ref-158)
158. See “Infiniband” on Wikipedia: http://en.wikipedia.org/wiki/Infiniband [↑](#footnote-ref-159)
159. See “Message Passing Interface” on Wikipedia: http://en.wikipedia.org/wiki/Message\_Passing\_Interface [↑](#footnote-ref-160)
160. Run MPI Applications on the A8 and A9 Compute Intensive Instances: https://msdn.microsoft.com/library/azure/dn592104.aspx [↑](#footnote-ref-161)
161. Microsoft Power BI: http://www.microsoft.com/en-us/powerbi [↑](#footnote-ref-162)
162. besides HDFS, Azure HDInsight service also uses ASV Azure Storage Vault which is Azure Blob Storage for its map/reduce and other Hadoop jobs [↑](#footnote-ref-163)
163. Leveraging a Hadoop cluster from SQL Server Integration Services (SSIS): http://msdn.microsoft.com/en-us/library/jj720569.aspx [↑](#footnote-ref-164)
164. Azure Machine Learning: http://azure.microsoft.com/en-us/campaigns/machine-learning [↑](#footnote-ref-165)
165. Microsoft Azure Essentials: Azure Machine Learning: http://aka.ms/AzureML\_pdf [↑](#footnote-ref-166)