GET READY FOR CLOUD COMPUTING

A comprehensive guide to Virtualization and Cloud Computing

Fred van der Molen

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Get Ready for Cloud Computing

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A comprehensive guide to Virtualization and Cloud Computing

Fred van der Molen (Lead Author)

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Colophon

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Foreword

Ever since I was a boy, I have been fascinated by clouds. I would look up into the sky over England, intrigued by the various shapes and sizes that foretold of good or inclement weather. As this was England, it was more often than not inclement.
With a little imagination, it was also possible to see faces, animals, cars and other shapes. Sometimes the clouds seemed so low you could almost touch them but they were of course always out of reach.
.
In many ways things have not changed as the meteorological clouds of my youth have transformed into the technological clouds of the 21st century. As someone passionate about technology, I find it amusing how the similarities between the two work as a metaphor for where we are today.
As a boy vision and creativity could turn any abstract cloud into a sensitive sheep or a wily wolf. As a CTO, I seek to combine that same vision and creativity to turn abstract technological clouds into concrete services and solutions that improve the life of our customers.

As clouds drift across the sky they mutate, altering their appearance so that new shapes reveal themselves. In the same way the cloud configurations which are emerging in the market are continually adapting and changing their shapes to provide new possibilities..
Even as the real clouds seemed deceptively within reach before, they were always beyond my grasp. Today, certain cloud technology often seems closer than it really is and solutions can still be tantalizingly past our reach.

The good news is that the technologies that underpin the ***Cloud Promise*** are evolving at a tremendous pace and new configurations of solutions are rapidly becoming reality. Of these developments, virtualization has probably had the most impact to date. As stimulating as the technologies themselves may be, the real excitement will come from the new operating models that envelop and empower the cloud solutions. They will provide the real key to unlocking new opportunities for our clients and society as a whole.

Just try to conjure up what the world could be like in ten years. Hundreds of cloud providers both broad and niche, offering their components, stacks, patterns and solutions to a global market through dynamic contracts and spot pricing. A cloud futures market with hedging may well be commonplace. Through this ongoing brokerage and arbitrage, many assets as we know them today might even cease to exist and become but liquid commodities.

In this book you will read about the State-of-the-Art as it is being created in the top technology companies and service organizations around the world. You will also catch a glimpse of things to come. This book is part of a significant investment by the major technology vendors and companies such as ING to get our people and our customers ready for the change ahead. This book is part of a larger project for in company trainings on virtualization and cloud computing including a series of training courses with international certification as well as e-learning, videos and a business simulation.

I would like to thank the many people who have made this book and the additional educational offering possible. I believe it to be the most comprehensive vendor neutral but vendor rich view into the state and future of one of the most important developments this century. Special thanks go out to my colleagues at the Enterprise Cloud Leadership Council, Sean Kelly, Michael Harte and Eric Pulier for their leadership, inspiration and vision.

My admiration also for Peter Hanselman and Rosanne Poolen who worked tirelessly within ING to bring this project to fruition and my Chief of Staff, Alan Nance for his vision in putting together the overall concept.

I believe that the great expectations inherent in the Cloud Promise can be achieved. Success will depend on how we combine vision and creativity with the technology available. This will be a stimulating journey that may well entail navigating a few sensitive sheep and wily wolves along the way. In that respect nothing has changed since I gazed into the sky as a boy.

Tony Kerrison, Head of Infrastructure Services, ING

Acknowledgments

We are very grateful to various people for helping us get this publication done in record time.

Our first thanks goes to several IT leaders at ING who provided us the motivation and support to author this publication, including Tony Kerrison and Alan Nance. The fact that we received abundant access to experts and information within ING around the large-scale adoption of Virtualization/Cloud Computing technologies gave us various insights into the experiences of a large user organization. These will certainly benefit other organizations undertaking the journey to adopt the cloud computing in the coming years.

Next we would like to thank the review board, which worked diligently under very tight deadlines to review the content. The review board included Hans Beers from IBM, Eric S. Charlesworth from Cisco Systems, Derek Cockerton, from HP, Edward Newman from EMC Corporation, Steve Peskin from Virtual Clarity and Arjan Woertman from ITpreneurs. Many of these organizations further shared content, insights and experiences in the form of white papers, case studies, articles and other documents as inputs for this publication.

We would also like to thank Nic Barnes and Danny O'Connor (ING), Ton van den Berg (T-Systems), Glenn Brouwer (IBM), Derek Cockerton (HP), Ton Hofhuis (VMware), Ed Houweling (Microsoft), Paula Laughlin (EMC), Martien Ouwens (Oracle), JP Van Steerteghem and Brian Gracely (Cisco) for their contributions.

A very special thanks is also due to Fred van der Molen and Peter Hanselman who took on the challenging role of producing this unique publication in record time.

Finally, we are also thankful to the people at ITpreneurs and Van Haren Publishing whose cooperation and teamwork made this publication a reality.

Sukhbir Jasuja
CEO, ITpreneurs

How This Book Is Organized

Have you heard a lot about cloud computing lately? Are you wondering what the impact of the cloud will be on your organization? Then this book is for you. It isn't intended to be an exhaustive technical manual on virtualization and cloud computing strategies. In fact, we try to avoid IT jargon whenever possible. In clear, concise language, ***Get Ready for Cloud Computing*** will help you understand the basic underlying principles of cloud computing and guide you in making a business case for implementing the cloud in your organization.

In the first two chapters, we offer insights into the history and visions behind cloud computing concepts. These chapters provide an overview of the cloud model and the forms it is taking. We also explore how organizations can profit from cloud-enabling technologies and how they can incorporate them in their own IT-infrastructure.

Chapter 3 deals with Virtualization. In this chapter, we take a look under the hood of the cloud. This section is a bit more technical, but you will find it worth while, as the concept of virtualization is really at the heart of the cloud.

Part II of the book offers in-depth articles from industry experts who are working with leading IT vendors in the field of cloud computing.

In Part III, we share a number of interesting case stories, covering a broad range of virtualization and cloud related issues. Some of these stories were made available by vendors, others were researched by our editorial team.

As you will see, there are compelling reasons to get up to speed on this exciting and rapidly-evolving new dimension of the Internet. Reading ***Get Ready for Cloud Computing*** is the perfect start.

Fred van der Molen (Editor/Leading Author)

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Get Ready for Cloud Computing

Part I
An Introduction to Cloud Computing and Virtualization

Understanding the Cloud

Fred van der Molen

1. Understanding the Cloud

1.1. Introduction

"You may recall the childhood story of Chicken Little being hit on the head by a falling acorn", is the surprising start of an article about cloud computing by HP's Keith Jahn. In 'Making the Cloud Relevant' he memorizes the story about the seemingly life-or-death journey of a frantic hen who feels obliged to inform the king about her finding that the sky is falling down. Along the way Chicken Little gathers supporters. Later on the group runs into a fox who advices them to take a shortcut so they will arrive more quickly to the king. According to Jahn, there are two popular endings to this old story:

- The animals are eaten by the fox and never see the king, espousing the age-old lesson of "do not believe everything you hear."
- The king's hunting dogs intervene and dispatch the fox enabling the king to hear the story, teaching a lesson about courage and perseverance in pursuing goals.

What, if anything, does this story have to do with IT?
Jahn explores in the article a scenario that IT organizations could face in the not too distant future, brought about by the advent of the cloud phenomena - one that forces radical change or results in dire consequences for IT as we know it, and perhaps even removing the function altogether.

Although the metaphor is a bit limp, IT veterans probably have heard "the sky is falling" stories twice a decade. The IT sector is full of hypes. Both versions of the Chicken Little story have materialized. UNIX did not kill the mainframe; the thin client did not kill the PC; the year 2000 bug did not stop the world; the old economy survived the new one.
But once in a while there is indeed a real "inflection point", as Intel's former CEO Andy Grove put it: a moment in history in which the way of doing things fundamentally changes, mostly due to new technologies. Such a moment gives new players a chance to break into existing and divided markets. At the same time, it can be the beginning of the end for old companies which do not recognize the new and unexpected challenges.

In 2003 Nicholas Carr wrote his bombshell book "Does IT Matter?"

The introduction of the PC was such a moment, and even more so the establishment of the World Wide Web. Most probably the introduction of the iPhone will turn out to be an inflection point as well. And now we have cloud computing, which will turn out to be yet another disruptive technology.
Cloud computing is the next stage of the Internet computing model, one in which business will consume services, not technologies. And these services will be ready to run, available outside the office walls, and be paid for on the basis of usage, just like water or electricity.
As the cloud and services model matures, business will be able to solve old problems more inexpensively and rapidly. And what's more: they will be able to address new challenges that they were never able to address before.

Back in 2003, Nicholas Carr wrote his bombshell book "Does IT Matter?". Some of his predictions have come true already. The cloud will force business to change, and ever more, force IT providers and departments to change. This will not happen overnight. It will not

be next year, or in a year or two, but more and more companies will have a real choice to source services wherever they like: inside the organization or from any provider, whether it be Google, IBM, Microsoft, Amazon, T-Systems or any other cloud vendor.
Cloud computing is driving a fundamental change, enabling IT managers to treat infrastructure as a common layer, on which they can provision services to users faster in a much more flexible and cost-effective way. From a technology point, the journey to the cloud is more an evolution than a revolution. It builds on decades of IT innovation and is hampered at the same time by decades of infrastructure and application development. And yes, there are legal, security, and compliance issues. But at the end of the day, the potential benefits of the cloud computing paradigm are too overwhelming to be ignored:

Benefits cloud computing:

- Improved business agility
- Reduced capital expenditure
- Increased end-user productivity and collaboration
- Reduced energy consumption

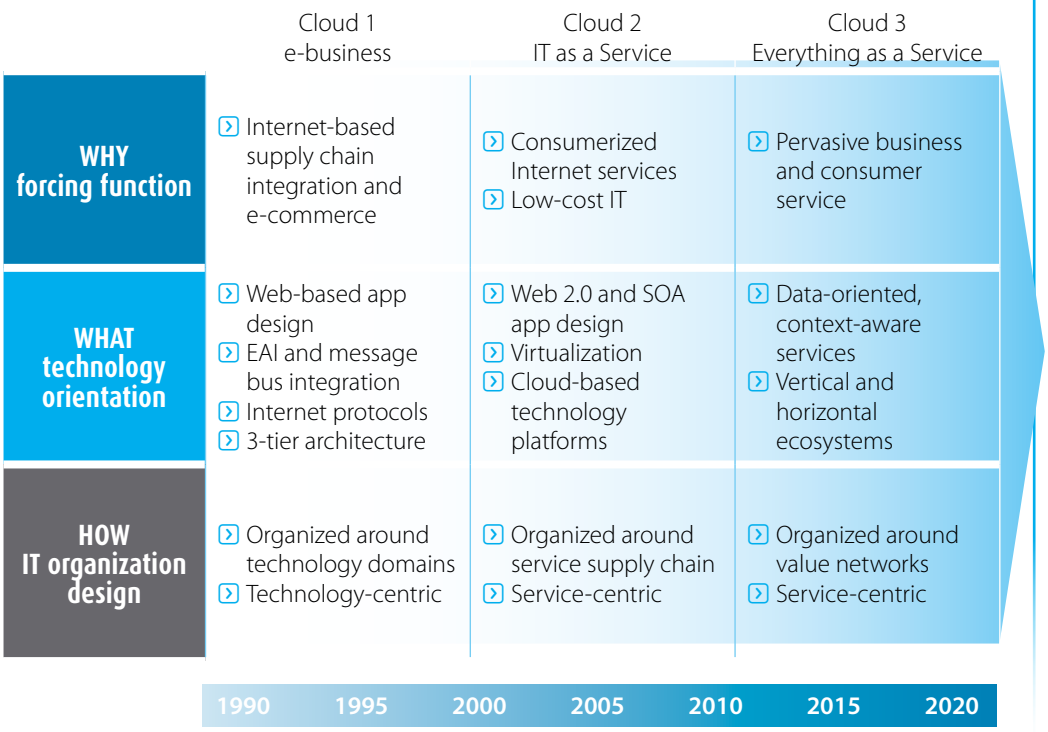
1.2. A Brief History of Cloud Computing

Referring back to old mainframe-practices from the seventies, some IT veterans dismiss cloud computing as just 'time-sharing on the Internet'. That's a witty thought, but not even half the truth.
But yes, the cloud is not new. Existing technologies, such as grid computing, utility computing or adaptive computing, mark the infrastructure path leading to cloud computing; application service providing (ASP) signifies the growth towards the provision of programs. The cloud is the next stage in the evolution of the Internet. It provides the means through which everything from personal collaboration, computing power, storage to business processes is delivered to you as a service. Services like Gmail, YouTube or credit card validation are good examples; you get the service when you need it and wherever you are, provided of course you have an Internet connection.

By the way: the term "cloud" originated in the telecommunications world. Telecommunications networks and the Internet were visualized on technology diagrams as clouds, signifying areas where information was moving and being processed, without the average person needing to know exactly how that happens. And actually that's a still central feature of the cloud: the customer asks for and receives information without knowing where it resides or how the services in the cloud fulfill the request.

The history of cloud computing started in the nineties with the creation of the World Wide Web. With the Mosaic browser, Internet-based computing took off. From a business perspective, it brought us virtual shopping experiences and chain integration. The concept of e-business acquired a foothold in almost every company. As a valuable side-effect, consumers became acquainted with leading-edge technology while searching for information, doing online shopping, communicating with their friends and family, watching movies, or managing bank accounts. The seed of the cloud was sown.
The next generation of cloud services was driven by these consumer experiences: available 24/7, an intuitive user interface that didn't require training, and comprehensive self-services,

Figure 1.1 - The evolution of Cloud Computing.
Source: 'Making the Cloud Relevant', HP White Paper



from opening a new bank account to booking a holiday trip. Technology evolved to create rich interactive web interfaces and service-to-service interaction. Welcome to Web 2.0! Interestingly, innovation in consumer-oriented services progressed far beyond business applications. Web 2.0 more or less forced its way into the enterprise on the backs of the employees. Cloud services like social networks and collaboration tools, for example, changed the way business people access and share information. At the same, time companies like Google and Amazon started offering their storage and computing capacity to business and consumers.

Today, most of the attention around cloud services in the enterprise is focused on these kind of techniques and sourcing alternatives for IT capabilities; it all comes down to IT as a service. Using standardized, highly virtualized infrastructure and applications, this new approach can drive higher degrees of automation and consolidation, thus reducing costs.

The evolution of cloud computing is now entering phase three: Everything as a Service. At the end of the day most of the enterprise infrastructure and applications will be sourced as services in an on-demand manner. This can be in a "public cloud" like Google or within the (control of the) organization as a so-called "private cloud".

1.3. Business Innovation

The cloud service orientation is also generating new ideas for business innovation. Companies are beginning to discover new sources of value in cloud services. First of all, the

cloud can lead to cost and efficiency savings. Second, the cloud model can eliminate some of the constraints inherent to traditional architectures and service delivery models, for example in chain integration and collaboration.
Meanwhile, business people are attempting to further exploit the service orientation to remove complexity in their processes. The new generation of "digitally native" employees visualize new opportunities but feel "held hostage" by their IT department. This is adding stress to the already troubled relationship between IT departments and the rest of the organization.

While many companies are wrestling with the technology transitions required to move to Web 2.0, the volume of services in the commercial cloud marketplace is increasing and new web technologies are emerging.
Not surprisingly in today's economic climate, the desire to save money is present in all IT-discussions.

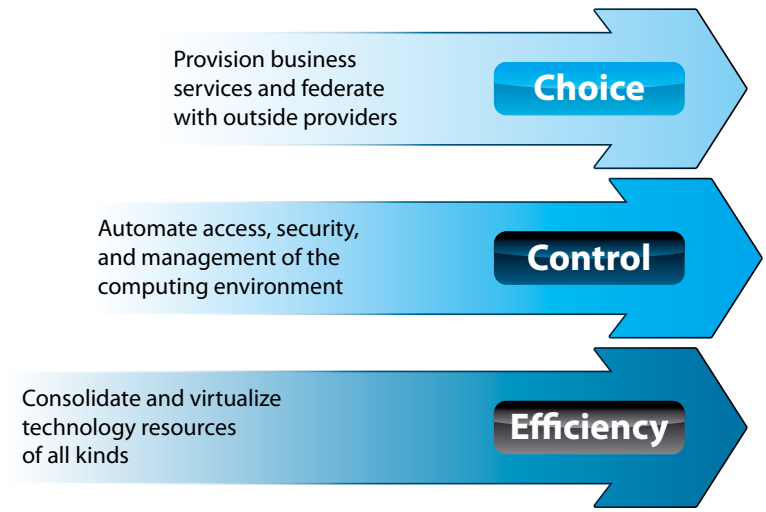
> Cloud computing is a potential cost saver but does not always save money

Cloud computing is a potential cost saver but does not always save money. It can drive costs up if it is used to replace on-premises work with an exact duplicate in the cloud. Knowing when to redesign is critical.
As we move beyond traditional computing paradigms, we enter an era where everything becomes a service: from software as a service to business processes as a service. This will inevitably change the way we think about running our businesses.

A New Era of Innovation

The IT industry has seen several paradigm shifts over the past four decades. Mainframe computing enabled businesses to automate manual processes and achieve growth not limited by the number of employees; the personal computing era empowered professionals to run their businesses based on individual data and applications. Then a decade of network computing and client/server-technology established a new level of information exchange

Figure 1.2 - Journey to the private cloud.
Source: EMC



inside and between companies. According to Forrester Research, each of these revolutions brought with it new economies of scale. The cost-per-transaction, the cost of automating office and desktop processes, and finally the cost of network bandwidth fell quickly and enabled business users to apply ICT solutions more broadly to create business value. Forrester believes that cloud computing will help unleash the next wave of tech-enabled business innovation, which it calls Smart Computing.

The Forrester researchers (The Evolution Of Cloud Computing Markets, July 6, 2010) see three major market forces both enabling cloud computing as well as driving its adoption by users and service providers:

1. **IT Becomes Embedded in the Business**
   The Internet has already driven a gradual migration of functionality from applications designed for single departments or processes toward resources that are shared and interconnected. Offering IT resources as a paid service makes users aware of costs, unlike traditional measures such as the speed or volume of technology infrastructure. Buyers are more likely to judge technology investments in business terms, measuring technology value in terms of improved business outcomes. Forrester refers to this evolution as the shift from information technology to business technology.

2. **Shared Service Architectures Mature**
   The massive shift toward Internet-based shared IT resources reinforces the preference for one-to-many service architectures. Internal consolidation and virtualization of data centers is just the beginning. The quest for higher utilization of IT resources then leads users to try out shared platforms operated by external service providers, which have significantly higher levels of resource sharing and lower costs per unit.

3. **Technology Populism Spreads**
   As the overall population becomes more Internet-literate, consumers are using technology to manage and integrate their private and business lives. The rapid evolution of the personal cloud services and mobile digital devices raises business users' expectations for immediate, universal access and unlimited scale of technology resources.

Forrester: cloud computing will help unleash the next wave of tech-enabled business innovation

According to Forrester, cloud computing has already had an impact on many of the segments of the $2.4 trillion worldwide spend by businesses and governments on ICT products and services. At the highest level, cloud computing changes how customers deploy software applications and middleware, it draws spending from portions of the outsourcing market, and it cannibalizes customer investment in hardware and data centers.

1.4. Is It a Cloud? Characteristics

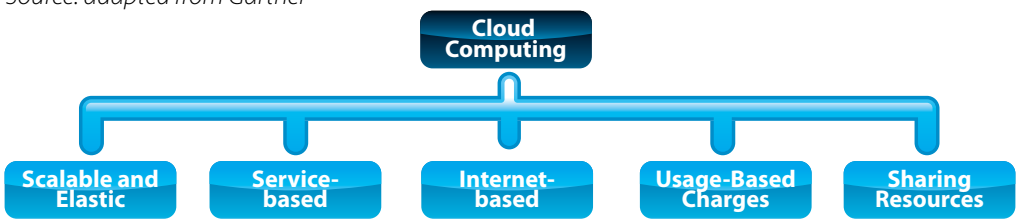
Back to basics. Time for a reality check. We know the IT industry is good in generating hypes. Every vendor is talking about cloud this and cloud that. Some of them just seem to have replaced the word "Internet" for cloud or re-labeled everything as a cloud service. But what makes a cloud a cloud?
As we have seen in the three cloud diagram in Figure 1.1 cloud computing is still an evolving paradigm. For the moment, let's stick to the definition of the US-based National Institute of Standards and Technology (NIST).

Definition NIST:

> Cloud computing is a model for enabling 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.

That's quite a mouthful. Essential is that the cloud is not defined as a set of technologies but rather a model for delivering, managing, and consuming information technology resources and services.

Figure 1.3 - Characteristics of Cloud Computing.
Source: adapted from Gartner



According to NIST, as well as others, the cloud model is composed of five essential characteristics, three models, and three service models. We will examine these one by one. First, the essential characteristics (we derive these from different sources, including NIST and Gartner):

Scalable and Elastic

In a cloud world, a service provider can't anticipate the usage volumes or demands for services. It doesn't need to either. The service is always on (24x7), scalable, and flexible by design. The cloud is elastic like a rubber band. To the consumer, the available resources appear to be unlimited, and they can be accessed and purchased in any quantity at any time.

Service-based

In a cloud world users can unilaterally provision an application, server time, storage or a business process, as a service. This can be done on-demand without requiring human interaction.

Internet-based

And yes, this is an Internet World, so cloud services have standardized web services interfaces. These standards promote use by heterogeneous client platforms (e.g., PCs, thin clients, mobile phones, and PDAs).

User-based Charges

Sorry, there is no free lunch, unless you would like to introduce an advertising-driven revenue model like Google inside your business. Cloud systems have a metering capability appropriate to the type of service (e.g., storage, processing, bandwidth, or active user

accounts). Resource usage can be monitored, controlled, and reported. And yes: your cloud services provider sends you a bill, just like the power company.

Sharing Resources

Cloud services are multi-tenant, either at the hardware layer or software layer, but ideally at both. This means that a single instance of software, and the computer platform it runs on, serves multiple clients. There is a sense of location independence; the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or data center). Sometimes this is needed for legal reasons.

1.5. Cloud Delivery Models

When one says "cloud computing", people probably first think of services offered by well-known companies such as Amazon, Google, Facebook, Twitter, YouTube and Salesforce.com. This is the "public" cloud, where you can use resources for free, or rent computing and storage capacity, as well as a growing array of business applications and services. Making a division between the public, private and hybrid deployment model is a popular way of making a "slicing" into cloud computing.

Public Cloud

A public cloud is made available over the Internet to the general public or a large industry group and is owned by an organization selling cloud services. These services are offered via the Internet in a standardized, self-service, and pay-per-use form. The public cloud is a mass-volume, highly standardized IT services market with low margins.
From a vendor perspective: the cloud provider is the vendor. Besides relative newcomers as Amazon, Google, and Salesforce, well-established Internet providers (Terremark, T-Systems) and traditional IT-vendors (IBM, HP, Microsoft, SAP, Cisco, EMC and Oracle) have entered this market.

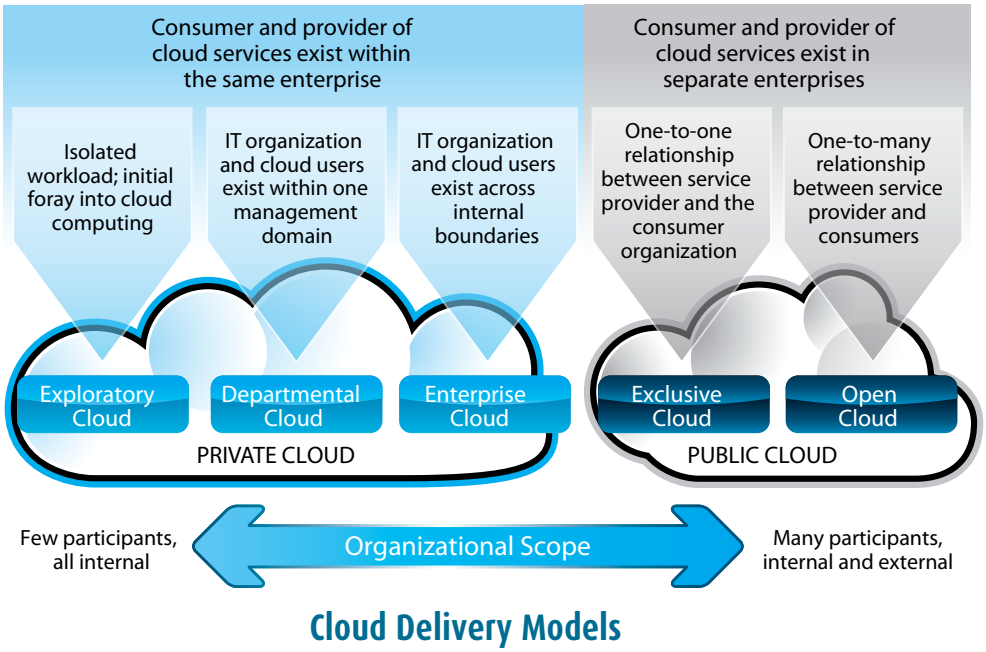
Private Cloud

A private cloud is operated solely for a given organization. It may be managed by the organization itself or a third party and may exist on premise or off premise. Aside from the underlying technology, an important difference between large-scale corporate data centers and private clouds is the governance model. In the cloud model "the business" really is the customer. The risk of fluctuating utilization is on the IT side rather than on the business side. A challenging new perspective for CIO's is that the IT department is not a cost center anymore; it is a service provider that is financed by contributions from the business units.
From a vendor perspective, the private cloud is essentially a market for licensed tools, hosting and consulting.

Hybrid Cloud

The cloud infrastructure is a combination of private and public clouds that remain unique entities but are bound together by technology that enables data and application portability. It combines elements of public and private clouds, including any combination of providers and consumers, and may also contain multiple service layers.

Figure 1.4 - Cloud subtypes.
Source IBM, White Paper, Defining a Framework for Cloud Adoption



In cloud computing literature, one will find all kind of refinements, like the delivery model subtypes in Figure 1.4 from IBM. This figure shows a cloud computing adoption framework starting with an Exploratory Private Cloud at the left to an Open Public Cloud at the right. These distinctions are relevant for a more targeted discussion of roles and responsibilities for both the provider and the consumer of cloud services, but we will be tackling that in this introduction.

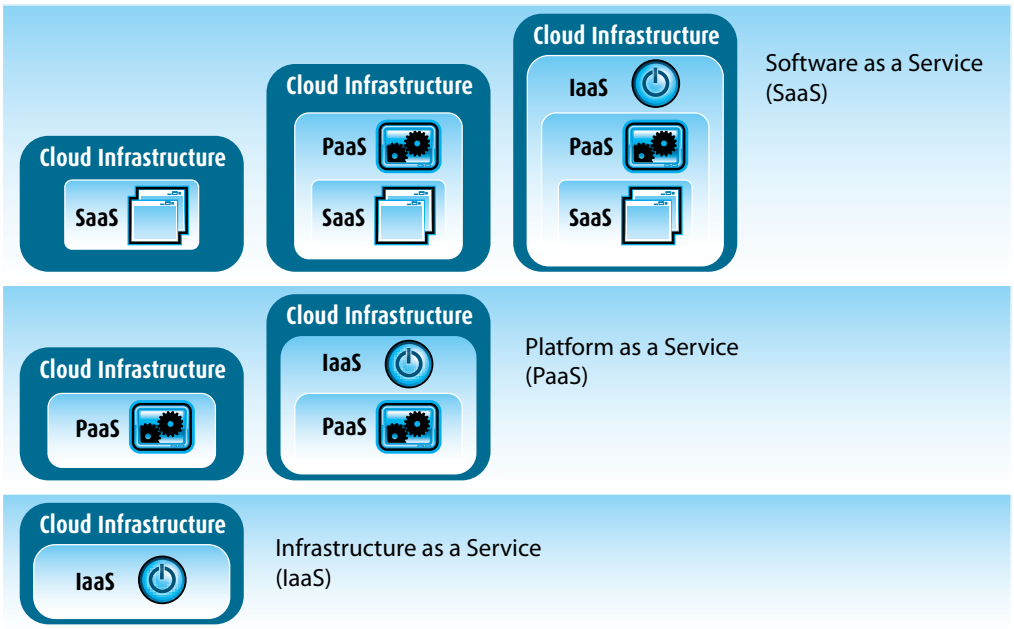
1.6. Cloud Service Models

Let's look now at the common types of service models.

Infrastructure as a Service (IaaS)

These type of cloud services provide on-demand, pay-as-you-go access to computer resources, (servers, networking and storage). This also includes the delivery of operating systems and virtualization technology to manage. The customer is renting computing power rather than buying computers and software. This service is typically paid on a usage basis - for example, by the hour or gigabyte transferred - or as a fixed fee for a virtual device with an agreed-upon capacity and configuration.
These kind of services involve an straightforward Service Level Agreement (SLA), in terms of availability, capacity and performance. Examples of cloud infrastructure providers include Amazon Web Services, Terremark Infinistructure, Hosting.com and Savvis.

Figure 1.5 - Service Models.
Source: NIST



Platform as a Service (PaaS)

These services deliver compute capability (infrastructure) that is typically aimed at developers or advanced IT users. The customer deploys applications created in house or acquired elsewhere using programming languages and tools supported by the provider. The customer does not manage or control the underlying cloud infrastructure (network, servers, operating systems, or storage), but has control over the deployed applications and possibly application-hosting environment. PaaS addresses the need to scale without upfront investments. A possible disadvantage is certain degree of vendor lock-in. There are proprietary elements in most platforms. Examples of PaaS are web servers, Force.com (the development environment for Salesforce.com) and the Google App Engine.

Software as a Service (SaaS)

When we move up in the stack, the next layer is SaaS. The service provider offers the customer the ability to run predefined business applications that are hosted by the provider. SaaS has its roots in the nineties in hosting operations carried out by Application Service Providers (ASPs.) As a cloud service it comes with pay-per-use, self-service and dynamic scaling characteristics. SaaS-applications are already widespread. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities. Applications in this space include Salesforce.com, Microsoft SharePoint Online, IBM LotusLive, Expedia.com and Google Apps. Other major vendors like

SAP, Oracle and HP all have SaaS offerings as well.
The most obvious advantage in buying software as a service is that the customer does not have to buy any hardware or software. You can share information with external partners more easily without having security concerns. There are no upfront investments and the price is likely to be lower. Environments such as Facebook, YouTube, Google Apps, and others are all designed for massive scaling. As a customer you make advantage of the economy of scale of these providers. And what's more: the provider does all the heavy lifting in the data center. Biggest disadvantage is probably the limited configuration options. One should be aware of security and compliance issues as well.

Business Process as a Service (BPaaS)

This service combines application cloud services and the shared services model in which a single organization delivers business services, such as purchasing, holiday booking, employee benefits management, help desk or procurement, to multiple internal or external consumers. This has its roots in the traditional outsourcing business, where complete business processes – such as IT maintenance – were turned over to external experts.

How to Catch a Cloud?

Fred van der Molen

2. How To Catch A Cloud?

2.1. Business Drivers for Adopting Cloud Principles

A lot has been said already about the proclaimed benefits and business drivers for cloud computing. We will now investigate that in detail. Of course there are drawbacks and risks too. We will get to those later as well.

Improved Business Agility

'Agility' has become a familiar buzzword at CIO-seminars lately. And indeed, cloud computing services make it easy to add new users, new capabilities or increase or decrease capacity. Flexibility and faster time-to-markets make a difference in an age when markets are evolving more and more rapidly. Not only do successful companies recognize market opportunities early but they are also able to respond to them quickly as well. Therefore, organization and business processes should be geared towards agility and flexibility.
Using a cloud computing model, IT staff can meet changes in user loads quickly without having to invest and engineer for peak loads. Elasticity is a benefit when enterprises are growing, providing the opportunity to purchase capacity on the margin at predictable costs. And, equally as important, the cloud also provides the means to scale down a service cost-effectively and quickly when it is no longer needed or the demand diminishes.

As cloud computing converts fixed costs into variable costs, it releases capital for investment in other areas

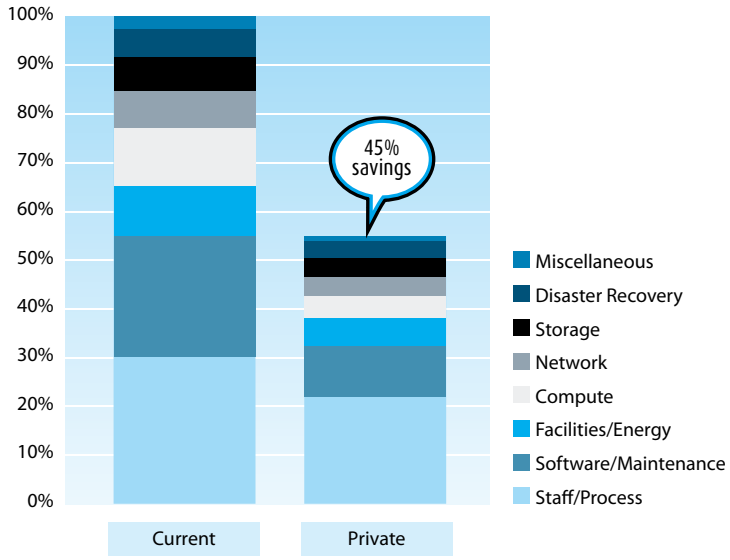
For example, your department wants to try out a new business application. Instead of embarking upon a decision-making trajectory of perhaps months in duration, you now can try out, develop, and even test a new application without first investing in hardware, software, and networking. This can have a very positive impact on innovation.

Reduced Capital Expenditure (CAPEX)

With external clouds, you do not have to invest upfront in infrastructure. This enables enterprises to minimize capital expenditures and still increase functionality. As cloud computing converts fixed costs into variable costs, it releases capital for investment in other areas. Or, it can enhance the balance sheet strength of a company.
With cloud computing, you can consume new resources as a service, paying only for what you use. Clouds also enable IT departments to save money in the long run on hardware-investments, application implementation, maintenance and security costs. If your organization were to start from scratch, you could reach costs benefits with a private cloud infrastructure up to 45%, according to a study of vendor EMC. (Figure 2.1) IBM studies give about the same cost reduction figures, but the actual reductions an organization will achieve will of course vary depending on the starting situation.

Although a cloud scenario can drive costs up at first if used to replace on-premises work, hardware is perhaps the most obvious cost reduction factor. In the long run, cloud infrastructures, running multiple virtual systems per physical host, are cheaper. One should not however underestimate the complexity of the overall management of these virtualized

Figure 2.1 - Representative cost benefits for a private cloud infrastructure. Source EMC



environments. New virtualization-aware system management tools will be needed. Once these are deployed, however, cost savings are substantial. Computing power, storage and network components will be utilized far more efficiently; fewer administrators can manage a larger number of servers. Cost-reduction opportunities can be found in maintenance, system administration, facilities, energy consumption, and so on.

Increased End-User Productivity and Collaboration

Cloud computing increases user productivity and collaboration. With a cloud solution users can access services regardless of location or device. And they can easily share information with colleagues or partners.

Less Energy-Consumption

"Going Green" is a important focus for many enterprises. Clouds and virtualization enable organizations to reduce power consumption and space usage.

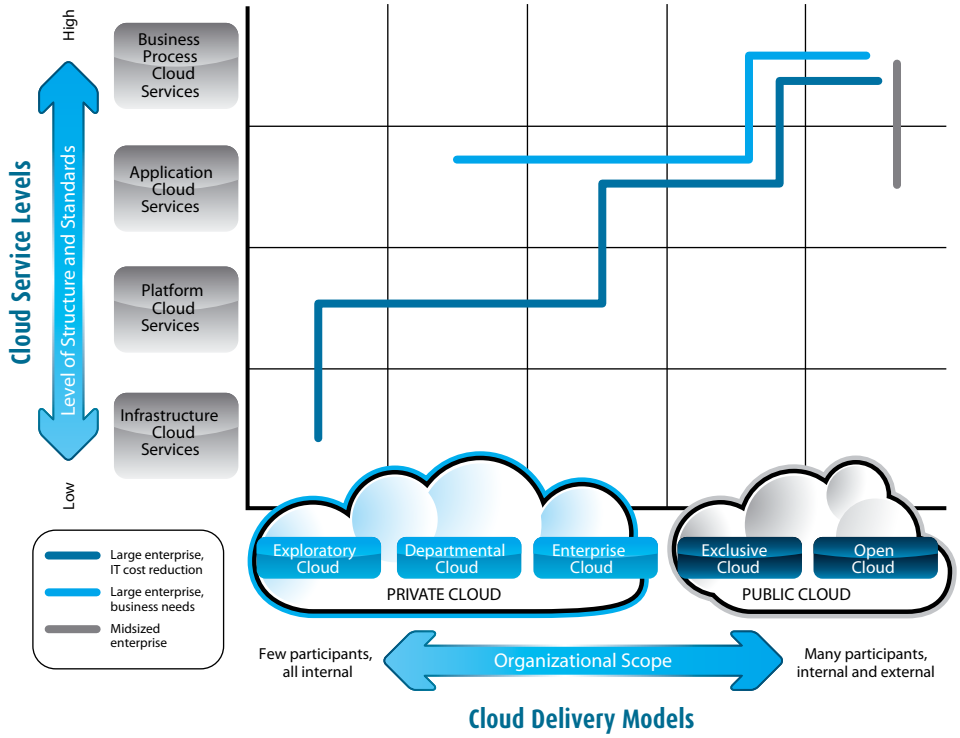
Improved Reliability and Continuity

Maybe this should stay a secret, but cloud providers have less downtime than most companies with internal data centers. Cloud computing, private or public, can also cost-effectively provide redundancy sites, facilitating business continuity and disaster recovery scenarios. The virtualized and automatically managed environment of a (private) cloud infrastructure enables better compliance with information management and privacy regulations, more secure remote access to corporate information, and faster and more reliable backup and recovery of information systems.

2.2. Defining a Roadmap for Cloud Adoption

The public cloud consists of a fast-growing array of services offered by very large and relatively new players like Google and Amazon. The unit cost is low and the scale is enormous. A small business can source its entire IT-infrastructure and some or most of its business applications to the public cloud.
For startups, the public cloud is probably a no-brainer. However, for large and established organizations, with business-specific legacy applications and a lot of sensitive information, relying heavily on the public cloud might be infeasible and unwise. As Gartner Group explained in 2009, "For most IT services, cloud services do not exist, are not proven, do not meet service-level requirements, do not meet regulatory or legal requirements, are not secure enough, or all of the above." (Thomas J. Bittman, "Private Cloud Computing: The Steppingstone to the Cloud," June 2009)
By law, companies remain responsible for their data, but you may not know where your data is being stored (that alone can violate national laws) and how exactly it's being protected. All this will changeover time. Public cloud offerings are expanding and improving all the time, and it may be the best source already for selected (especially new) business applications and services. For example, many large enterprises have decided to use public cloud services for mail, collaboration, human resource management (HRM), education, and customer relationship management (CRM).

Figure 2.2 - Potential cloud adoption pathways.
Source IBM: Defining a framework for cloud adoption



So, companies need to think about a adoption strategy of cloud services. Potential pathways will vary according to the chosen delivery model and service layer, as well whether the migration to cloud is driven by the business or IT.

Figure 2.2 gives a visual map of potential cloud adoption pathways from IBM. Such visualizations can help organizations identify challenges that should be considered prior to cloud implementation.
Large organizations may be early adopters of public clouds for new services, but will more likely start with developing cloud delivery skills and experience. And yes, the question of outsourcing will be on the table again.
The goals in implementing an "exploratory cloud" - similar to a proof of concept - are to develop customer and provider competencies and create awareness of cloud architectural and management requirements. A key integration requirement for private clouds is virtualization of servers, storage and networks. (We will look under the virtualization hood of the cloud in Chapter 4.)
In a "departmental cloud", the goal is to expand use of cloud computing to users who are not familiar with cloud capabilities, and to begin developing business support systems and operational support systems capabilities.
One major roadblock will be that existing applications need to be retrofitted to run in the cloud or phased out. Large public cloud service providers won't be of much help here. They are as inexpensive as they are inflexible. Everything has to be done their way, although they do update their services partly based on user input.

Large public cloud service providers won't be of help here. They are as cheap as inflexible.

So at this stage at least, public clouds are not the natural habitat for the majority of large-enterprise IT. However, a private cloud, internally or externally hosted, is a different story. It combines flexibility and price-tag advantages with the traditional management control over service delivery, security and compliance. The private cloud also offers a sensible migration path for existing applications and preserves investments in infrastructure, applications, and information. Most large organizations will likely follow a hybrid approach, in which the advantages of the private cloud can be combined with the access to innovative and on-demand services the public cloud offers.
In this "federated" world, a private cloud serves as the gateway and control mechanism for public cloud services, yet another reason why the private cloud is the place to start for large enterprises.

2.3. Preparing the Organization: Technology

Introducing cloud services doesn't require a big bang approach. Public cloud services can be introduced – at least from a technology perspective – gradually as needed. A migration to a private cloud is not about embarking upon a whole new set of activities or a massive implementation project. From a IT perspective, you can look at it as a better way to organize and manage existing technology resources. The cloud is the name for the overall coordination mechanism for a variety of technology improvement initiatives that companies need anyway, have under way, or in some cases have completed. This includes:

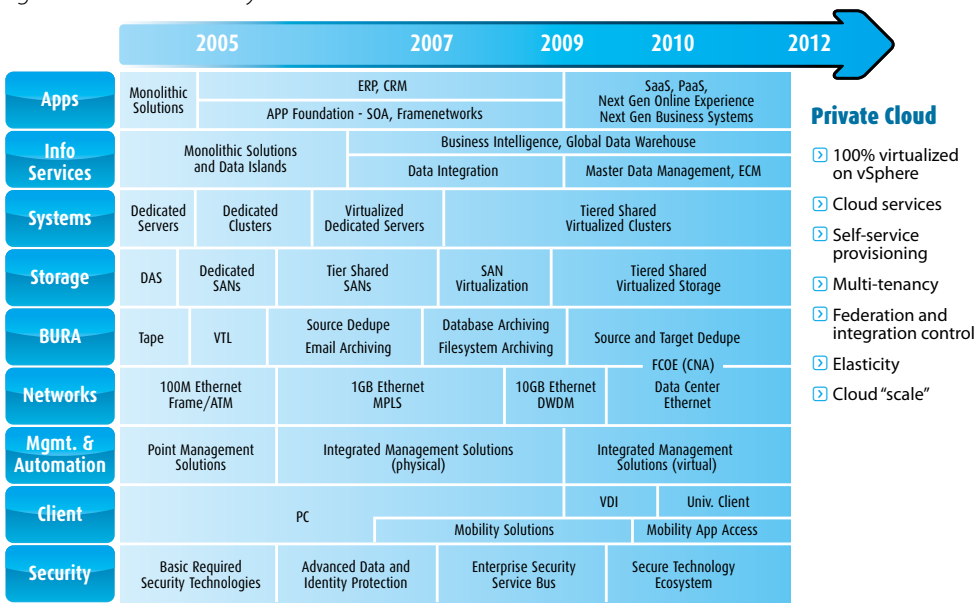
- Consolidating servers, storage, networks, and other IT resources
- Virtualizing technology resources, including information and applications
- Organizing and provisioning IT offerings as business services

- Structuring and managing IT as a shared services organization
- Automating technology resource and security management
- Building standard interfaces with compatible service providers
- Making effective use of selected public cloud services

(Source: EMC, "Private Cloud Means Business")

In an interesting whitepaper, Journey to the Private Cloud, IT company EMC has documented its own migration process . We have enclosed a short version of that in part III of this book and will not elaborate on it here, but Figure 2.3 gives an idea of the comprehensiveness of such a program.

Figure 2.3 - EMC's Journey to the Cloud



The private cloud is the umbrella for all these improvement initiatives, and a private cloud roadmap can be the means of integrating these efforts.

What Not to Put in the Cloud

The business value of a private cloud grows as more resources are included. That doesn't mean all resources should go in the cloud. EMC defined these exceptions:

- Specialized business applications, such as analytical trading systems in financial services. These tend to be complex "workhorse" systems within specific business functions, and the value of pooling these resources is limited.

- Applications and databases that must absolutely be walled off from the rest of the computing environment for legal or regulatory reasons, such as local privacy laws. Companies tend to segregate such resources physically to be safe. However, with the help of state-of-the-art virtualization management methods, you may be able to move many of these sensitive assets to a private cloud.
- Applications that have been written, and their performance optimized, with specific systems architectures in mind. This is a temporary impediment. Over time, companies may choose to retrofit such applications.

(Source: EMC, "Private Cloud Means Business")

2.4. Preparing the Organization: Change Management

First of all, whether IT departments like it or not, cloud services are invading organizations. It is happening. In almost every organization, there are "stealth clouds" that the IT-staff doesn't know of. Employees use iPhones, LinkedIn, Google Docs, iTunes and YouTube at home and expect this level of ease-of-use and functionality at work too. Self-service is how users want to interact. Users will implement business applications outside a company's firewall, if the internal IT services are not meeting their demands. Saying no is not always an option. Business users shape their expectations based on their experience as consumers. Inside the company walls, they may encounter user unfriendly tools and services with less functionality, slow or unresponsive systems, and less freedom to solve problems. A frequently heard question: why does it take seconds to find information on the Web and ages to find information on the corporate intranet? Good point.

The introduction of cloud services will have a major impact on your whole organization, not just the IT department. It will change the way users request and access applications and services. Tomorrow specific business units will not have their own servers, applications and even system administrators. Maybe virtualization has removed that mindset already. A cloud computing strategy is in this respect more of an evolution than a revolution. What never changes is that IT departments must embrace new technology - cloud computing models - while serving a diverse base of users, managing existing systems, and integrating a variety of existing applications.
Companies will all have their own and very different "journeys to the cloud". At the end of the day, the focus will be on the delivery and access to a service or application, and not on a hardware-based infrastructure.

The last decade we have had countless of books on the subject of "business IT alignment". This alignment between the business and IT is in contrast to what is often experienced in organizations. Often IT and business professionals are unable to bridge the gap between themselves because of differences in objectives, culture, and incentives.
Cloud computing is not the panacea for this, but the cloud approach will change the overall consumption and procurement model of IT to a utility-based model. This is a challenging new perspective for CIOs: the IT department is not a cost center anymore; it is a service provider that is financed by contributions from the business units.

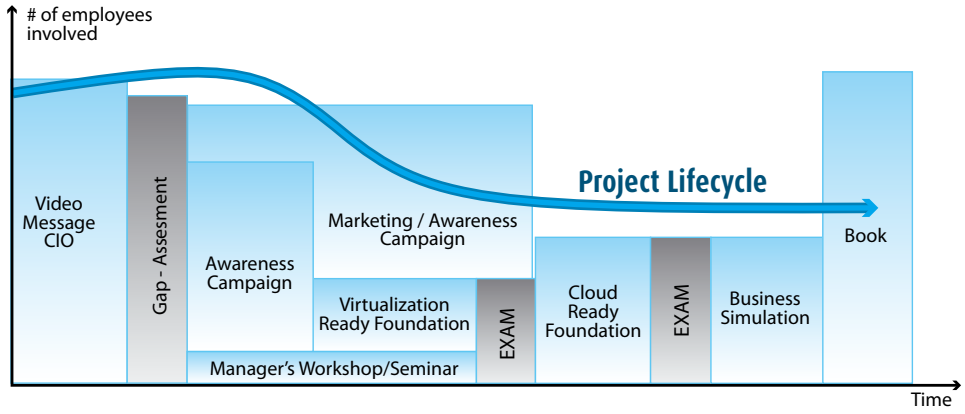
Change! Yes, We Can?

Today organizations can choose whether they implement business services in-house, have them hosted, outsource them, or acquire them through the cloud. In a few years from now, most organizations will have a hybrid environment. Enterprises that decide to utilize the cloud will need to make sure that it supports corporate and IT governance requirements. At a more detailed level, there are issues of emerging standards, business process management, and the overall issues of managing costs.

Companies will want to examine their most strategic business processes, intellectual property, and business information, and determine how these computing assets will be delivered in the future. Which ones are ripe to take advantage of the cloud, private or public? Which ones will be delivered the traditional way?
The journey to the cloud will be both a challenge as well as an opportunity for internal IT departments. The skill set for developing and maintaining virtualization infrastructures and cloud delivery services are quite different. A variety of traditional IT jobs will disappear, particularly since many of existing (legacy) applications will need to be retrofitted or replaced to take advance of the benefits of virtualization and the private cloud.
Therefore virtualization programs can be a natural starting point for (additional) outsourcing.

Companies need to develop frameworks for cloud adoption, specifying roles and responsibilities for both (internal or external) providers and consumers of cloud services. Roadmaps need to be established, training programs set up. The board needs to spread the message. Figure 2.4 show the roadmap the ING Bank has developed for the training program as part of the change campaign inside the organization. An interesting aspect of this is the development of a certified training program for both virtualization as cloud skill sets. This is a small part of ING's comprehensive cloud strategy.

Figure 2.4 - ING has adopted cloud/virtualization certification, training and other activities as part of a change campaign



To Begin

There are many types of cloud computing, with different service models and delivery models. According to Gartner, Software as a Service (SaaS) is in many ways the most mature of the cloud types. The Dutch electronics giant Philips for example has cloud-based SAP services. The Telekom subsidiary T-Systems provides these services for Philips via a private cloud. This outsourcing contract is part of a global program in which Philips is consolidating and modernizing its IT infrastructure.
Gartner often sees SaaS coming into an organization through departmental business purchases. Sometimes the IT department is the last to find out. Gartner: "This frequently means that IT has to clean up poor contracts, bad technology choices that prohibit good application integration, or, worse yet, SaaS services plagued with operational issues such as inadequate security."
Gartner advices companies four basic steps in order to "get in front of the SaaS curve":

- **Step 1:** Analysis. Determine the value of SaaS or a specific SaaS-application. As with any technology or delivery model, there are pros and cons to consider.
- **Step 2:** Develop a SaaS policy and governance document in a collaborative effort between the business and IT. This document should be neutral in regard to any particular application domain. Such a police will ensure consistency of SaaS deployments across your organization.
- **Step 3:** Vendor evaluation. If you did your homework in Step 2, you should have a reputable process that can be applied to each new vendor selection process.
- **Step 4:** Develop an integration road map on how SaaS applications will integrate with on-premises applications and other SaaS solutions deployed. Clear approaches should be identified (e.g., real-time, batch, etc.), including potential integration providers that can be used.

Source: Robert P. Desisto, " Four Steps to Get in Front of the SaaS Curve", Gartner, June 2010

2.5. Limitations and Challenges

Cloud architectures are maturing rapidly, but today's cloud computing solutions still have drawbacks and limitations, such as security and compliance concerns, proprietary application platforms that require redevelopment time, and the inability to move to another provider. According to IDC-research, back in 2008 security was already a major concern of CIO's (IDC Enterprise Panel, 2008), followed by performance and availability. At the 2010 RSA Conference, the buzz still focused on the security cloud service providers offer. The CSA's (Cloud Security Alliance) Top Cloud Threats Report issued a warning that some cloud services have unwittingly hosted malicious software.
So, it is obvious that businesses will feel more reassured if providers can demonstrate effective policy enforcement and prove compliance to national laws.

Security and Compliance

As mentioned above, security and compliance rank as CIOs' top concerns with cloud computing. These concerns are primarily valid for the public cloud. Private clouds offer enhanced security based on existing best practices in organizations. All of the existing

security infrastructure, including firewalls, encryption, and passwords, remains active in a private cloud.
With hosted private clouds, you have the same issues as with normal outsourcing: trust, encryption and compliance. The only new security-concern comes from the very nature of the cloud infrastructure: the fact you may be sharing cloud space with another organization. You cannot physically segregate machines. So there must be trust in the vendor's security model.
IT managers must look for the right balance between the security of an internal, dedicated infrastructure and the improved economics of a shared, external cloud environment. There is a lot going on in this arena with CloudAudits and similar initiatives.

With the public cloud, you lose transparency and therefore control. By law, a company remains ultimately responsible for its sensitive information. The simple fact that you may not know in which country your data is being stored violates some national data protection statutes (EU Data Protection Directive and U.S. Safe Harbor program). Not all cloud services indicate this information in service-level agreements, nor provide adequate audit trails.

Remember, on the other hand, that the cloud has potential advantages in terms of disaster recovery abilities, automated security management and availability. Also shifting public data to an external cloud reduces the exposure of the internal sensitive data.

Lack of Interoperability

A serious drawback is still a lack of interoperability between clouds, just as you have in the traditional IT world, by the way. The absence of standardization across cloud-based platforms creates unnecessary complexity and results in high migration costs. Each cloud vendor has a different application model. This is underpinned with proprietary, vertically integrated product offerings that limit platform portability. There are initiatives and pressure groups that strive for more standardization, such as the Open Cloud Manifesto launched in 2008 and the Open Data Center Alliance established October 2010.

Lack of Compatibility

Many existing cloud technologies do not offer full compatibility with existing applications. Some public clouds sacrifice application compatibility in order to provide improved scalability and other features. Converting MS Office documents into Google Docs, for example, will lead to loss of advanced layout and functional information.
This can potentially mean is that an IT department has to write entirely new applications specific to that cloud, or, at the very least, make very significant modifications to their existing applications or documents before they can be accessed from the cloud.

The Top Threats to Cloud Security

The Cloud Security Alliance, a group of customers and cloud vendors published in March 2010 a paper discussing the 'Top Threats to Cloud Computing'. We've summarized them:

- Abuse and nefarious use of cloud computing: hackers have embedded malicious software into some cloud infrastructures. CSA recommends service providers employ stricter initial registration and validation processes.

- Insecure application programming interfaces: Businesses use APIs to manage and interact with the cloud. However, a weak set of APIs exposes organizations to many security threats.
- Malicious insiders: Large companies initiate background checks on new employees. Why shouldn't you expect the same of your suppliers?
- Shared technology vulnerabilities: Virtualization hypervisors mediate access between multiple operating systems and the service provider's resources. But hypervisors have exhibited flaws that allow guest operating systems to gain inappropriate levels of control.
- Data loss/leakage: Data can be compromised in many ways, such as by corrupted backups or storage on unreliable media. Businesses should also demand providers wipe media before releasing it into the storage pool, and specify backup and retention strategies.
- Account, service and traffic hijacking: Mitigate the risk of unauthorized access to data by prohibiting the sharing of credentials between users and services.
- Unknown risk profile: How well do you understand your cloud supplier's security strategy and procedures? Ask for full disclosure of procedures for patching schedules, employee access to logs and so on.

2.6. Governance

Each of the cloud delivery and service models comes with a set of governance challenges. To make things more complicated, there is no clean dividing line between different approaches. Boundaries between private and public cloud vendors begin to blur, as vendors broaden their offerings. And in addition, hybrid environments - where on-premises applications will be used in collaboration with traditional hosted services and cloud services - will be the norm. This variety of models introduce new IT governance challenges, all the more so because new powerful suppliers with attractive functionality are arriving on the playing field. It definitely makes governance more complicated. But on the other hand, outsourcing did so as well.

Virtualization: The Real Thing

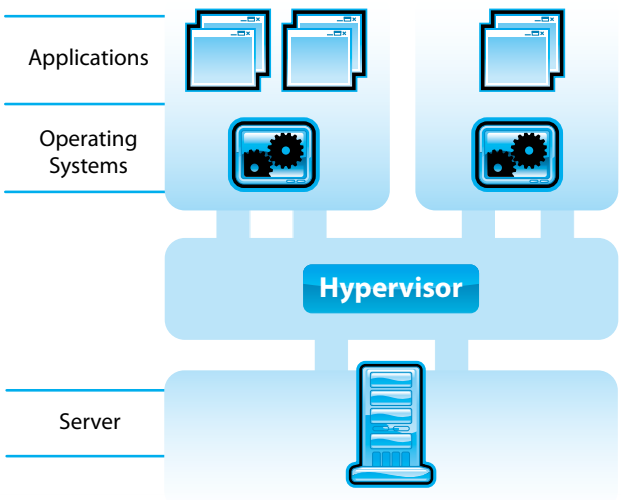
Fred van der Molen

3. Virtualization: The Real Thing

3.1. A Brief History into Virtualization

In this chapter we take a look under the hood of the cloud. We have to. The concept of virtualization is really at the heart of the cloud; virtualization is the enabling technology for cloud computing.
Virtualization is a set of techniques that allows making a split between physical and logical systems. It decouples users, operating systems, and applications from the specific hardware they use. It makes systems far more efficient.
Starting in the 1990s, the so called "x86-based" server market, based first on Intel and later AMD processors as well, grew exponentially. In contrast with existing enterprise servers (mainly mainframes or UNIX-based servers) x86-based servers had no easy way to move workloads around. Yet because these computers were cheap and ubiquitous, they became very popular. The underlying server paradigm was based on the philosophy "one application, one operating system, one server."

Figure 3.1 - The hypervisor makes a split between physical (server) and logical systems.



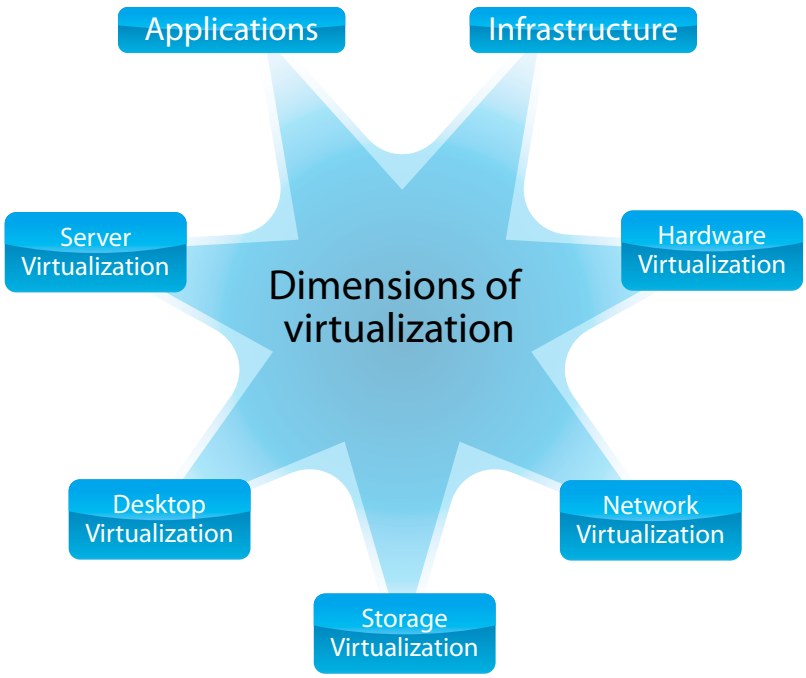
This approach came with a price: a very low system utilization. Utilization percentages less than 15 percent of their capacity were - and are - quite normal. Data centers were filled rack after rack with systems that were fiddling most of the time, but still consumed power and generated heat, day after day. Likewise, the capacity of integrated hard disks or direct-attached storage was largely wasted as well. The cost of managing all these boxes turned out to be extremely high as well; many administrators were required to maintain and upgrade all these systems.
For a long time, no one shed tears over wasted capacity on inexpensive servers; there was little you could do about it anyway. IT simply selected hardware that would meet performance demands and could cope with peak loads.

Virtualization, pioneered by VMware, introduced increased efficiency in the data center. The key virtualization layer, the hypervisor, makes a split between physical and logical systems by "fooling" the the operating system (OS). The OS still thinks it controls the hardware but is in fact contained in a "virtual machine" (VM).
This was a big challenge, but in the past decade virtualization software improved dramatically. Likewise new generations of processors, operating systems, and other server components became increasingly more VM-ready. You even can hear VM evangelists proclaim that "the hypervisor is the new operating system". And indeed, we are certainly moving in that direction. The virtualization layer is becoming more and more important, and we can foresee a future in which applications are tuned for running in a virtual machine directly.
The hypervisor, also called VM Monitors, let you run multiple operating systems simultaneously on one piece of hardware. You can have multiple instances of Windows, Unix and Linux virtual machines on one system. On large enterprise systems, you can run hundreds of virtual servers on one box. When it comes to hypervisors, there is choice now. Market leader VMware's (ESX) main competitors are Microsoft (Hyper-V) and Citrix Systems (XenServer). Due to this competition, entry level hypervisors are becoming a free ticket; vendors focus their business models on large-scale virtualization, tools, management, availability and disaster recovery software, and consultancy.
About 20 percent of new servers in Western Europe are used in a virtualized environment, according to recent IDC research (Q4, 2009).

Virtualize Everything

Most of the time when the terms "virtualization" comes up, server virtualization is meant. But you can virtualize almost every part of the IT-infrastructure. Computer scientists started with

Figure 3.2 - Dimensions of Virtualization



memory and ended up virtualizing almost everything: storage, servers, networks, applications and desktops.
In general, virtualization is a framework or methodology of dividing the resources of a computer into multiple execution environments.
Although much of the talk about virtualization involves server virtualization, other elements of the data center – e.g. storage and network - are intimately involved. If virtual servers are to move from place to place, they cannot depend on physical devices that are tied to a particular location. The underlying disks must be presented to all of the computers. This can be done with a conventional storage-area network (SAN). It can also be done by virtualizing the storage network.
Virtualization also leads to a more efficient approach for backups. In a virtualized environment, backups can take place in a central location rather than on the individual machines. This can lead to savings on licensing costs and processing capacity when engineered correctly.

The new kid on the block is desktop virtualization. In part III of this book, we have two case stories from organizations which have implemented a "Virtual Desktop Infrastructure", publisher Wolters Kluwer and the Dutch city of Zwolle.

3.2. Under The Hood: Different Approaches To Virtualization

The proliferation of Intel and AMD x86-based servers, and industry promotion of virtualization and cloud computing, makes it appear that x86 is the only virtualization game in town. But in fact virtualization was introduced in the 1960s and has been supported by many computer architectures ever since.
IBM first brought virtualization to their 7044 mainframe systems, later introducing the technology across a range of platforms. Other vendors of enterprise servers (e.g HP and Sun) worked with virtualization techniques as well, well before servers based on Intel-processors (and later AMD) found their way to the data center.

Software Virtualization

Software, or "full" virtualization, is a technique in which the hypervisor "traps" the hardware functions the operating system uses, emulating these operations and returning information consistent with what the real hardware would deliver. The bad news is that this intermediary layer reduces the system performance. The good news is that guest OS and most applications can run unchanged in such an environment.

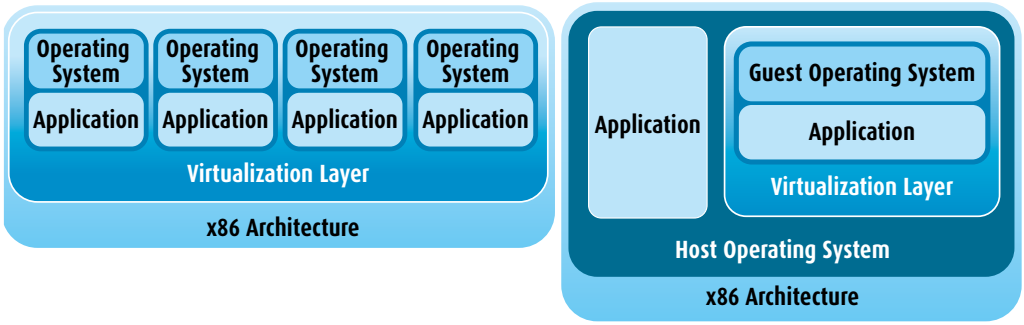
Paravirtualization

Paravirtualization is actually a new term for an old IBM concept. It is a technique that presents a software interface to virtual machines that is similar but not identical to that of the underlying hardware. Without going into details, this approach has the advantage that it avoids much of the trapping-and-emulation overhead associated with software virtualization. Therefore it can be faster. A major disadvantage is however that it requires a modified guest OS.

Hardware-Assisted Virtualization

Until 2006, virtualization on x86-based computers was largely software-based. To cope with the overhead associated with trapping and emulating tasks, processor manufacturers made extensions to the x86 system architecture. Key hypervisor suppliers support (some of) these extensions in their software. Hardware assistance refers to two independent technologies, Intel VT-x and AMD-V, created by respectively Intel and AMD, which improve processor

Figure 3.3 – Bare-Metal (left) and hosted hypervisor (right)



performance and support I/O virtualization and memory virtualization. They were introduced into CPU designs in 2005.

Bare-Metal Versus Hosted Hypervisor

Another distinction is made between bare-metal hypervisors and hosted hypervisors.
A bare-metal hypervisor runs directly on the hardware to control the hardware and to monitor guest operating systems. Examples are VMware ESX Server, Microsoft Hyper-V, Oracle VM Server for SPARC and Xen Hypervisor.
A hosted hypervisor runs within a conventional operating system environment. Examples are VMware Server, VirtualBox and Microsoft Virtual Server. Microsoft has a built-in virtualization capability in Windows Server.

3.3. Benefits

Cost-cutting is a major incentive for virtualization programs. According to a recent Forrester survey the majority of the interviewees said that they recouped their investment in virtualization within one year, with some companies breaking even within a few months. While most companies built their business case on a foundation of cost savings, better business continuity/disaster recovery and faster time-to-market for new applications/services were top motivators as well.

Key Capabilities

- Virtualization permits a single physical server to run multiple server instances .
- Automated management tools can allocate any amount of a physical server's capacity to a VM, scaling it up and down as necessary.
- The entire operating system and application environment is stored on a virtual disk, which can be easily duplicated to create new VMs.
- VMs are highly portable, allowing IT to quickly migrate them between physical machines to allow maintenance on the physical hardware or to balance workloads.
- If a physical server fails, its VMs can be quickly restarted on another system.

Virtualization removes the physical boundaries of your IT-infrastructure. In a virtualized environment, you cannot find your resources on a single computer in a given room. Your application is a workload somewhere in a data center or even somewhere in the cloud. This might sound disturbing, but it turns out to be highly efficient and reliable. Although virtualization processes are regarded complex, the technology and management tools have matured rapidly.
The potential savings in hardware, power, and cooling investment are substantial. In fact, server virtualization is a no-brainer today for most companies. However, according to a recent study of Forrester (The Business value of Virtualization, July 2009) many companies still haven't realized all the potential savings virtualization offers. This study shows that companies have virtualized between 10 and 30 percent of their physical servers. While they achieve rapid return on investment through hardware savings, firms appear to slow down after their initial successes, with many planning to virtualize just 50 percent of their systems. According to Forrester, "upfront planning can result in increased long-term savings."

The key benefits of virtualization are:

- Reduction of costs
- Increased flexibility, speed and scalability
- Quicker time to market
- Environmental benefits

Key benefits of virtualization are:

Reduction of Costs

Virtualization reduces investments in hardware, cooling and floor space. By making better use of IT hardware, virtualization frees up operating expenses that go toward "keeping the lights on" for reinvestment in business growth. Lower administration and provisioning costs

must also be included. One administrator can manage far more servers; new servers and new capacity can be deployed easily.
Before companies started to virtualize, the average server-utilization was about 10 percent. Beyond just hardware savings from consolidation, virtualization optimizes infrastructure costs and increases operational efficiency. An stunning example of consolidation is IBM's Big Green project in 2007 during which 3600 servers worldwide were consolidated in 30 mainframes running Linux.
Virtualization leads to significant savings in cooling and floor space too. In the Big Green project, IBM was able to reduce energy consumption by 80 percent, thanks to fewer systems, data centers and cooling facilities. In Part III of this book, several case stories illustrate the potential savings of a virtualized infrastructure.

Increased Flexibility, Scalability and Time to Market

Virtualization makes it easy to adapt IT assets to changing conditions, whether the changes are unpredictable and driven by the business cycle, or whether they are seasonal and predictable, such as peak sales seasons or quarterly and annual financial closing periods.
Virtualization helps end the "one application per server" model. As demand for a particular application increases, you can add capacity to that application. You can add a virtual server – even remotely - in a few minutes. Conversely, when demand decreases, you simply reallocate your virtual resources.
Virtual environments allow for shorter development cycles, allowing faster IT delivery to business needs.

Better It Management, Availability and Predictability

Although virtualized systems are more complex, at the end virtualization will reduce the demand on systems management significantly. In case of failure, recovery from downtime is faster and easier. Because workloads are dynamically migrated, it is easier to provide redundancy to support disaster recovery. Virtualization can also simplify the recurring task of upgrading applications or operating systems. End users will no longer receive regularly mails that servers are going down for routine maintenance.

Environmental Benefits

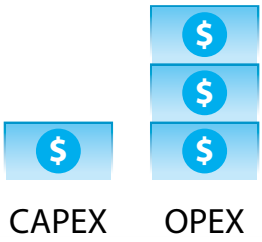
The carbon footprint of global data centers is approaching that of entire countries. Virtualization reduces the use of hardware, cooling and floor space. Virtualization has a significant impact on energy consumption and carbon emissions.

3.4. New Kid on the Block: Workplace Virtualization

Maintaining PCs has always been a burden to IT staff. Although this improved with new generations of computers, new versions of Windows and new extensions of the system management software, maintaining PCs has remained costly.

Early attempts to introduce inexpensive, centrally managed thin clients in the office all failed. They lacked the functionality and performance users demanded. This has now changed. We now have the Virtual Desktop, an evolving concept established in 2006 by the Virtual Desktop Infrastructure (VDI) Alliance. The conditions seem ripe for mass adoption: the technology is

Figure 3.4 - For every $1 spent on client hardware companies spend $3 to manage it. Source: VMware/IDC 2009



there, the ecosystem of vendors and integrators is broadening, and user adoption is on the rise.

We have in fact four flavors of desktop virtualization. These are terminal services (server-based computing), application streaming (client-based computing), virtual desktop streaming, and the virtual desktop. We will not further elaborate on this. We will also ignore the so-called "blade PC", another way to centralizing desktop computing by transferring PCs as a whole to the server room.

More important is the concept of desktop virtualization itself: it separates a personal computer desktop environment from a physical machine (the PC) by storing it on a remote central server. All software execution takes place on the server, and only the presentation layer is sent to the remote device. Access can be via a browser window, a remote session on a PC, or a thin-client device.
In this setup, it is not the server operating system that is being 'fooled', but the user. So when you log in on a device, you will see your familiar desktop appear. The computing paradigm shifts from device-centric to user-centric. Desktops are delivered as a managed service.

Hosted Virtual Desktops have ramped up since 2009. Performance problems and technology hurdles previously hindered acceptation, but the technology has matured in the last two years. Reduction of Total cost of Ownership (TCO) is a key driver, with estimates varying from 5 to 50% according to different sources. This giant discrepancy is partly explained by different starting points. If you compare a VDI-solution with a well-managed and locked-down desk-based PC environment, 50 percent savings would be too optimistic. But if your company has client/server networks in place in every branch office, very substantial savings are within reach.
Aspects such as flexibility, security and compliance are other clear advantages, with data being centrally managed and held in a data center instead of on distributed desk-based PCs and laptops.

Benefits Virtual Desktop solutions

- The individual enjoys much the same experience as before on the PC, but now regardless of location or device. Mobile support is easy.
- Devices (even public ones) can be securely managed. It make companies and employees more flexible.
- Devices can be simple and inexpensive thin clients. These devices have a long technical life, are cheap and easy to maintain.
- Cost reduction in workplace computing: acquisition, maintenance, and management costs of thin clients are low compared to fat clients.

Advantages and Constraints of Virtual Workplaces

The virtual desktop model offers a number of advantages over the traditional fat client model. Overall hardware and software expenses can diminish as users share resources allocated to them on an as-needed basis. Most workplaces can be provided with cheaper thin clients instead of PCs. Moreover, thin clients have a longer **refresh cycle** than PCs.
Virtualization improves the **data integrity** of user information because all data can be maintained and backed-up in the data center. It is simpler to provision new desktops and to deploy new applications or updates.

There are some limitations and considerations to desktop virtualization.
First of all, VDI deployment and management is complex. Small organizations should therefore only consider a hosted VDI-solution. Quality of network and systems management is vital. In the event of network failure, all users will be faced with downtime. In addition, there are potential security risks if the network is not properly managed.

VDI-solutions are currently an adequate solution for task-based users and knowledge workers. The latter group will encounter some loss of user autonomy and privacy, depending on the configuration. On the other hand, it frees the worker: he or she can login to his or her virtual desktop and access business applications, regardless of location or device.
Power users will be faced with performance problems when running demanding applications such as multimedia. They require fast machines with local applications, abundant memory and multiple displays.
But when working from home or on the road, they can also benefit from the virtual desktop.

In Part III we have two interesting case stories on VDI implementations.

3.5. Key Considerations When Adopting Virtualization Techniques

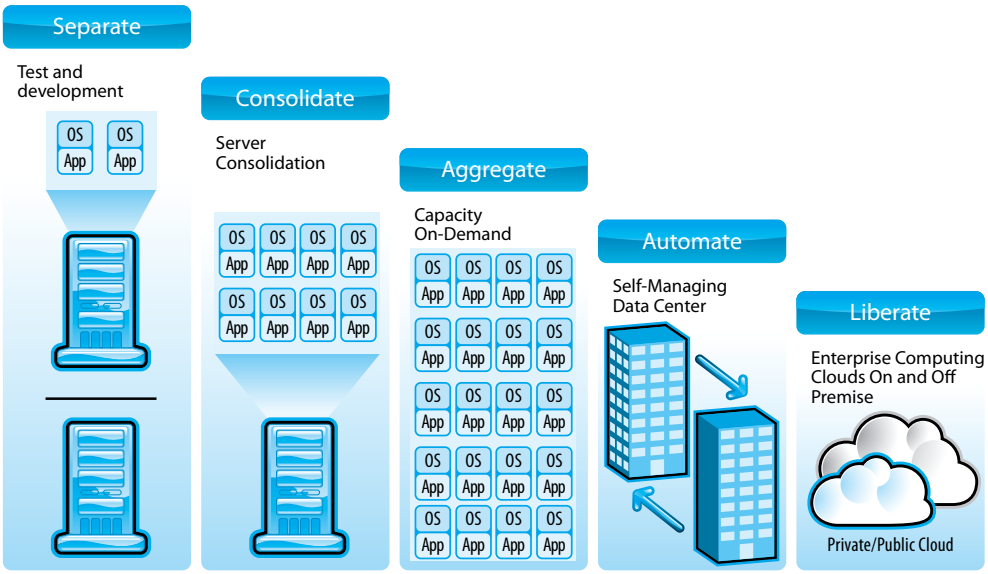
An organization planning to utilize virtualization is undertaking a journey that includes changes to the way people work to the type of skills the organization needs and the relationships of users with their IT providers. This is a journey that needs careful planning and a detailed roadmap.

But being a journey on itself, virtualization is just a stepping stone, an enabling technology, for cloud computing. Virtualization provides the key technology for server consolidation. The road to the cloud can be divided in four stages: consolidate, aggregate, automate, liberate.

We have elaborated on the benefits of virtualization, but there are some constraints too and things to consider:

- More centralized IT and adoption
- Complex management and changing roles administrators
- Application compatibility and rationalization
- Performance issues
- Risks: security, compliance and availability

Figure 3.5 - Four steps to the cloud



More Centralized IT and Adoption

Consolidating the IT-infrastructure goes hand-in-hand with centralizing IT responsibilities. There is no other way. This may lead to resistance, not only of departmental IT staff, but of business units as well. Therefore, central IT management needs not only to prepare a convincing story, but also has to win and earn trust. A lot of business users and departmental IT staff have mixed experiences with corporate IT. A good method of winning trust is a pilot project in which one or more business units are demonstrated the benefits of the new technology and new services. Perhaps the most obvious way to incentivize adoption is to ensure that users share in the financial benefit by charging a fair price for both virtual and physical devices.
If virtual machines can be provisioned quickly and offer demonstrably superior availability, they will be adopted without any further encouragement being necessary.
Indeed, in practice this easy provisioning can be a pitfall as well. "Virtualized" organizations may be confronted with a proliferation of servers because it is so easy to add new ones.

Complex Management and Changing Roles Administrators

The introduction of virtualization brings many changes that need to be reflected in the tools that administrators use to manage systems. Routines for software patches and making backups change. Monitoring tools that are used for correlating hardware and software events may no longer understand where dependencies lie, and so on.

The deployment and maintenance a virtualized infrastructure is a complicated management task. IT staff has to deal with a lot of dependencies: type of workloads, applications, operating systems, workloads, hardware features.

Different roles and responsibilities tend to come together. In a traditional environment you have separate administrators for servers, network and security. In a virtual environment, these roles are all part of the same management environment. This requires new procedures and policies.

Virtualization can start on a platform or departmental level. Enterprise-scale virtualization should be viewed as a new service. It will require new license agreements, service definitions, and the establishment of appropriate Service Level Agreements (SLAs) and Operational Level Agreements (OLAs). It will also require appropriate education of the workforce and is likely to need a degree of reorganization within the IT staff and the data center. This is a natural moment for outsourcing discussions to arise.

Application Compatibility and Rationalization

Many vendors explicitly certify their applications for virtualization on specific platforms. Few applications are entirely unsuited to virtualization these days. But there are exceptions. Some are just too old, others have very unusual requirements. And some life-critical applications and real-time applications, that have interfaces to special hardware, are not suitable to virtualization as well.
A virtualization program is the moment to rationalize the application portfolio of a company. This can lead to huge savings, due to standardization and modern licensing programs based on pay-per-use. ING for example wants reduce from 2500 to 1700 applications in the next few years and is aiming at a fifty percent reduction in the long term. Publisher Wolters Kluwer has reduced its number of applications from 226 to 90 in a desktop virtualization program. Both case stories are included in Part III of this book.
Some applications require re-engineering, some applications just cannot be virtualized. IT staff had to decide in consultation with business users what to do: just keep the old situation, develop a workaround or implement a migration plan.
Keep in mind that many problems encountered when migrating an application to a virtualized environment are not specifically related to virtualization itself. For example, IP addresses might need changing in configuration files or certificates might need to be updated. Issues that are expressly problematic for virtualization include requirements for particular hardware, such as hardware dongles. Solutions are often available but will need research and testing.
To encourage migrating, it may be helpful to establish appropriate price tags for virtualized and legacy applications.

Performance Issues

With the hypervisor you add an extra layer in your software stack, and extra complexity always comes with a price. Until 2006, virtualization on x86-based computers was largely software-based, and benefits often came at the expense of complexity and poor performance.
This has improved a lot, since Intel and AMD added features in their processor designs. However, optimization of a virtualized infrastructure still demands skilled personnel. Badly configured sessions can gobble up all capacity.
Another concern is that the virtual infrastructure – particularly the networks - will become so swamped with data traffic that performance will be impacted. To address this, it is important that organizations introduce monitoring and service reporting to demonstrate that the infrastructure is operating within capacity and effective governance mechanisms to take action when it is not.

Risks: Availability, Security and Compliance

Virtualization introduces new concepts and technologies and, as a result, introduces new risks.
The combination of new technologies and applications can prove instable. This can be addressed by standardizing and vigorous testing procedures.
When you virtualize everything, you virtualize problems as well. In other words, with the concentration of servers you inevitably concentrate risks. The impact of a human error can be amplified, concentrating servers can lead to a single point of failure, introducing virtual appliances can introduce unknown components and configurations into the IT infrastructure. All of this calls for a strict policies, a well-trained staff, and a rethinking of fail-over and disaster recovery procedures.