

Enterprise and Cloud Computing

# TOPIC 8 – CLOUD COMPUTING

# Agenda

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1. What is cloud computing?
2. Characteristics of cloud services
3. The Cloud Computing Stack
4. Industry Players
5. Service Level Agreements
6. Cloud Computing in Ireland
7. Green Cloud
8. Benefits & Limitations
9. Summary

# What is Cloud Computing

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- **Narrow Definition:**
  - virtual servers available over the Internet.
- **Broad Definition:**
  - Anything you consume outside the firewall is "in the cloud," including conventional outsourcing.

# What is cloud computing?

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**Wikipedia definition**: **Cloud computing** is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet).

Cloud computing provides computation, software, data access, and storage services that do not require end-user knowledge of the physical location and configuration of the system that delivers the services.

# What is cloud computing?

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National Institute of Standards and Technology (NIST): The NIST definition runs to several hundred words but essentially says that;

- *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.*

# Cloud Computing is a transformational shift from Technology to Service

## Technology

- Bits and bytes, speeds and feeds
- Technology focused
- Typically capital investment required
- Long leadtime
- Resource intensive deployment
- Lots of direct and indirect costs

## Services

- Service Level Agreement
- Hosted and Managed by 3<sup>rd</sup> Party
- Open pricing model
- Technology and Architecture is abstracted
- Ready to Go

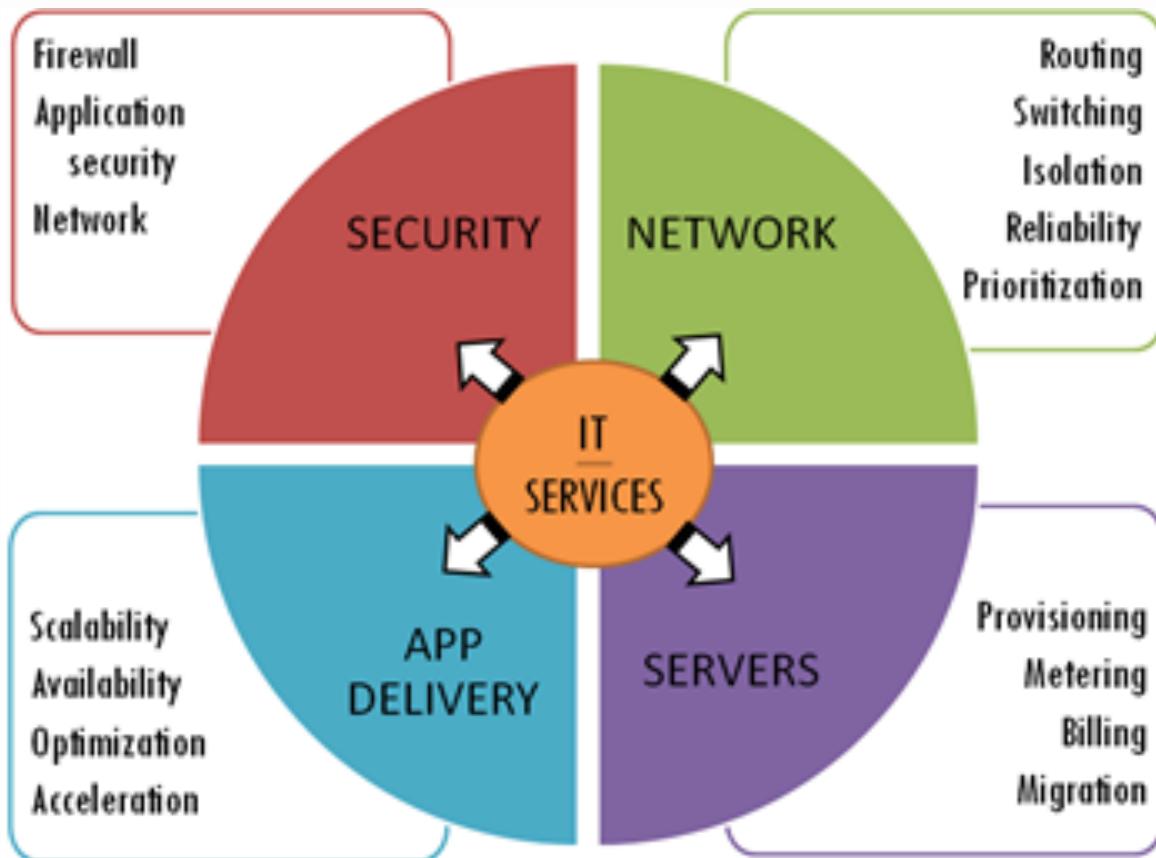
This transformational shift is driven by economic conditions and a change in attitude

# Characteristics of Cloud Computing

(ref:

<http://itredux.com/2009/10/11/defining-cloud-computing-for-business-users/>)

# Services typically on offer . . .

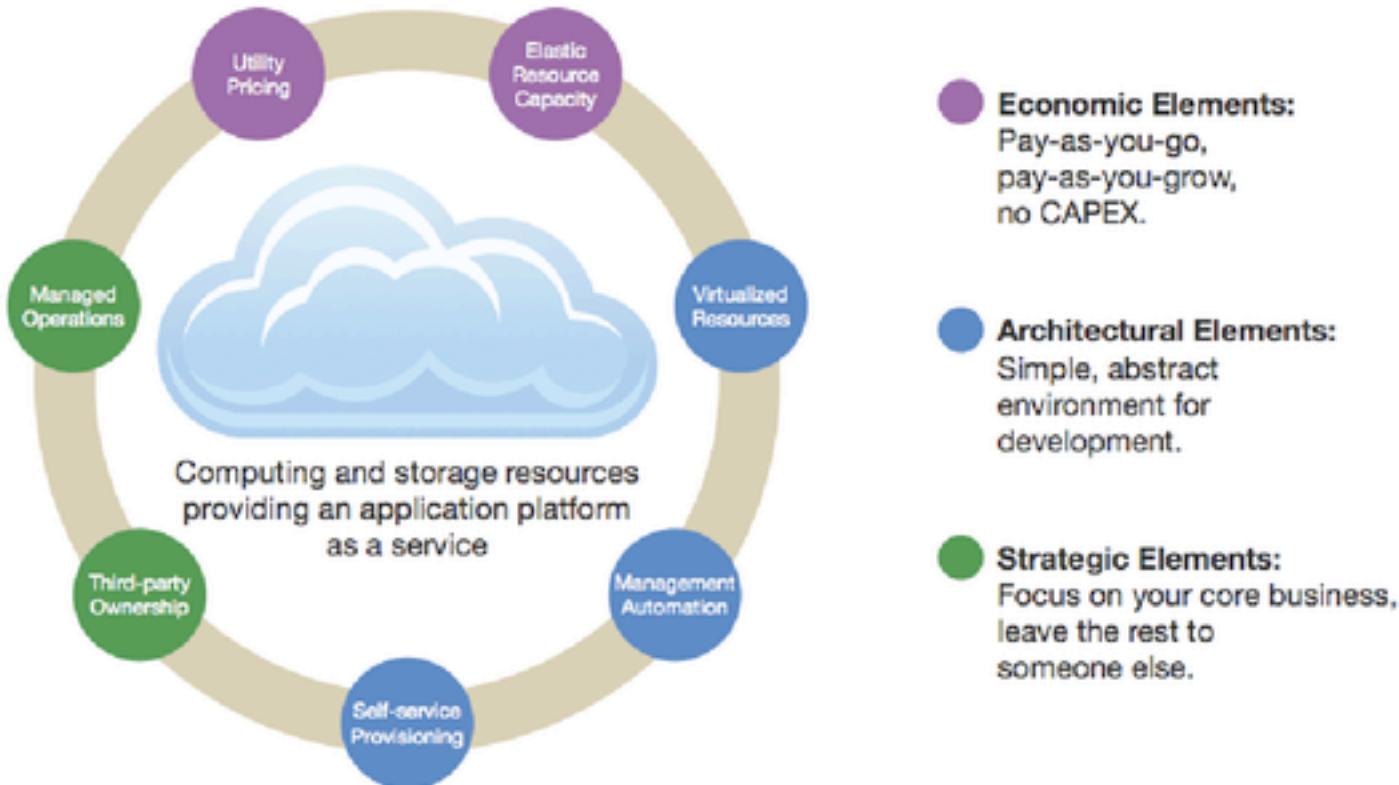


Ref:

<http://devcentral.f5.com/weblogs/macvittie/archive/2010/09/08/you-can't-have-it-as-a-service-until-it-has.aspx>

## The Seven Elements of Cloud Computing Value

Concept: MWD Advisors — [www.mwdadvisors.com](http://www.mwdadvisors.com)



# The seven elements of cloud computing

Cloud Computing can be defined as a set of computing and storage resources providing an application platform as a service. This platform is characterized by a unique set of economic, architectural, and strategic elements of value:

## 1. Utility Pricing

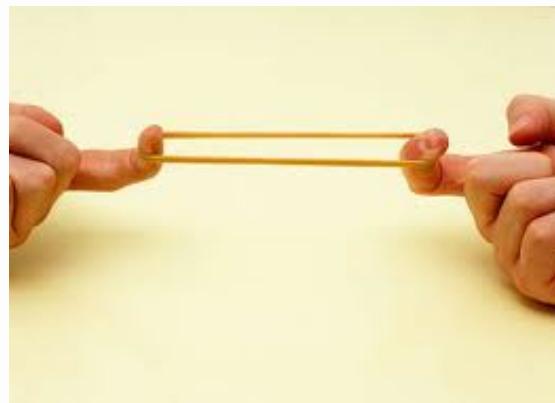
Cloud Computing is first a foremost defined by its **utility-based pricing model**. Users of the platform **consume** computing and storage services on demand and **pay** for them **as they go**.



# The seven elements of cloud computing

## 2. Elastic Resource Capacity

Cloud Computing differs from more traditional forms of distributed computing in the way it **scales** computing and storage resources **up** and **down**. Instead of tapping from a fixed set of resources, **users can add or remove capacity at will**, almost instantaneously, and only **pay for what they actually use**.



# The seven elements of cloud computing

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## 3. Virtualized Resources

Cloud Computing would not be possible without virtualization, because of the need for **multi-tenancy**. In order to benefit from economies of scale, cloud computing is predicated upon the sharing of a common infrastructure by multiple groups of users, often referred to as tenants.

Multi-tenancy can only be achieved through some kind of virtualization, either at the database level (Salesforce.com), application server level (Google AppEngine), kernel level (Red Hat), or CPU level (Amazon EC2).

Cloud Computing creates virtual slices of resources from clusters of servers and storage devices, perfectly sized to fit the specific needs of multiple users.

# The seven elements of cloud computing

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## 4. Management Automation

While a typical data-center may host every versions of every operating systems and databases known to mankind, thereby creating massive management overhead, Cloud Computing platforms usually standardize on a single kind of CPU (x86-based predominantly), a single hypervisor (VMware, Xen, etc.), a single operating system (some Linux distribution usually), and a single database (MySQL rules).

# The seven elements of cloud computing

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## 5. Self-service Provisioning

Provisioning is the setup required to either offer a new service to an existing customer, or offer a service to a new customer.

Because of virtualisation, in cloud computing new customers signing up are typically using existing technical resources, **reducing provisioning overheads** and so reducing setup costs.

**In theory, business end users can provision applications and user accounts in a few mouse clicks, and these become available instantly.**

# The seven elements of cloud computing

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## 6. Third-party Ownership

Cloud Computing is the transfer of ownership for resources to a third-party that specializes in their deployment.

As cloud computing is a form of outsourcing, it means the IT budget is now an **on-going, relatively small, recurring cost**, rather than a series of **large capitol expenditures** needed to invest in IT infrastructure or development.

# The seven elements of cloud computing

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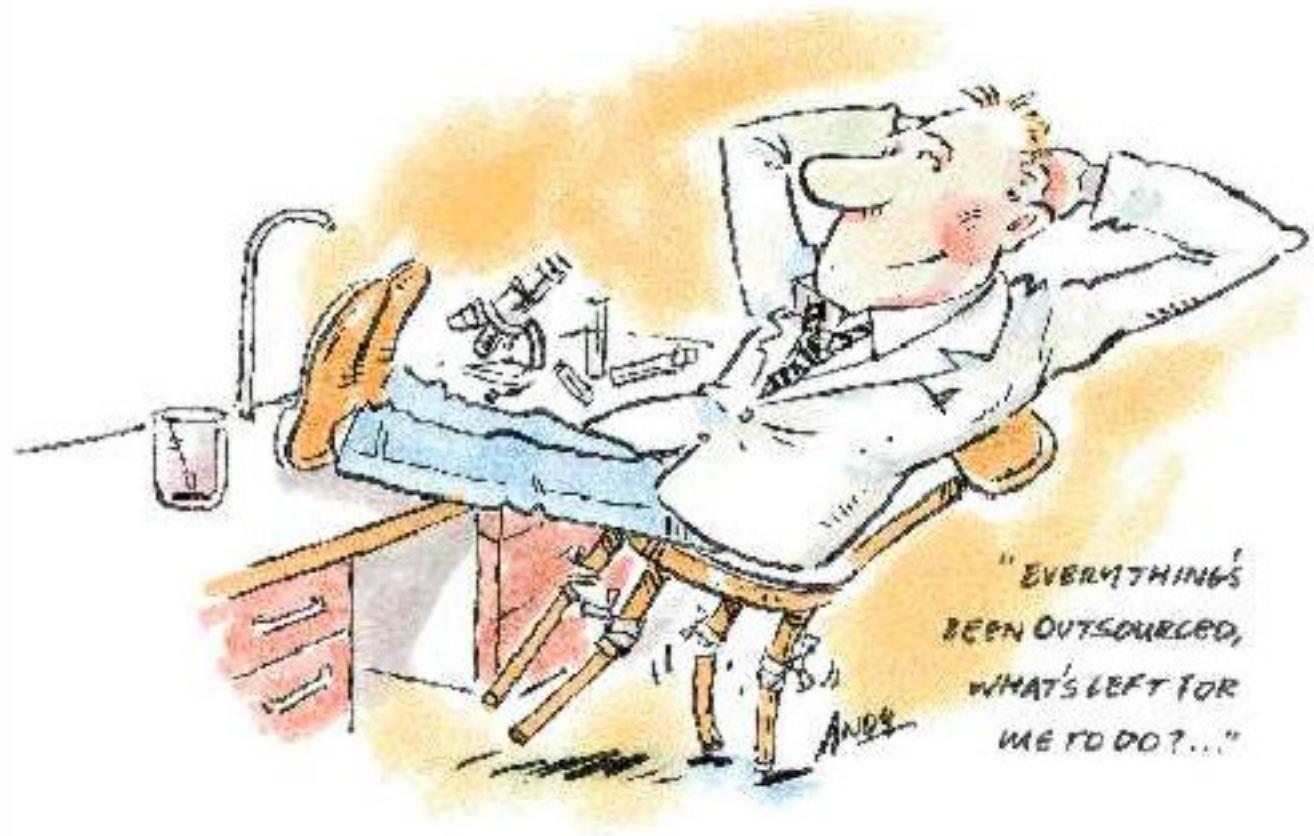
## 7. Managed Operations

Cloud Computing is finally about allocating human resources to tasks that will directly impact the business, rather than simply managing the infrastructure that supports it.

As such, Cloud Computing advocates a model according to which the **IT infrastructure is not only owned by a third-party, but managed by the third-party as well.**

Software upgrades, data backups, and the countless other tasks required to manage mission-critical business applications on a day to day basis become the responsibility of a third-party, according to **well-defined Service Level Agreements.**

# The seven elements of cloud computing



# Cloud deployment models

Public  
Community  
Private  
Hybrid

# Public/Private/Hybrid

A cloud can be private or public.

- A **public cloud** sells services to anyone on the Internet.
  - Currently, Amazon Web Services is the largest public cloud provider.

Everyone shares the same resources on the cloud.
- A **private cloud** is a proprietary network or a data center that supplies hosted services to a single user or organisation. It can be managed in house or externally. When a service provider uses public cloud resources to create their private cloud, the result is called a **virtual private cloud**.

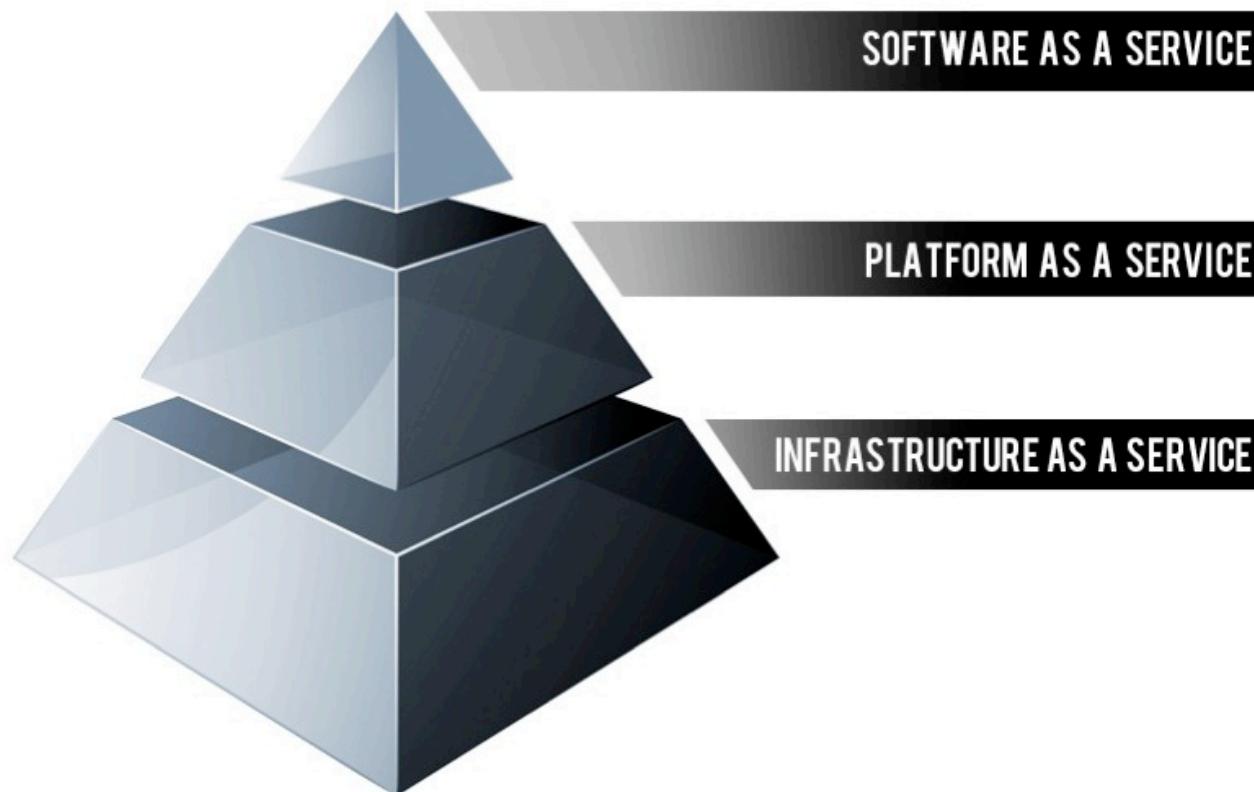
The private cloud can be shared by a **group** of organisations, which is called a **Community Cloud**.

# Public/Private/Hybrid

A **hybrid cloud** is a composition of at least one private cloud and at least one public cloud.

- A hybrid cloud is a cloud computing environment in which an organization provides and manages some resources in-house and has others provided externally.
- For example, an organization might use a public cloud service, such as Amazon Simple Storage Service (Amazon S3) for archived data but continue to maintain in-house storage for operational customer data.
- Ideally, the hybrid approach allows a business to take advantage of the scalability and cost-effectiveness that a public cloud computing environment offers without exposing mission-critical applications and data to third-party vulnerabilities.

# The cloud computing stack

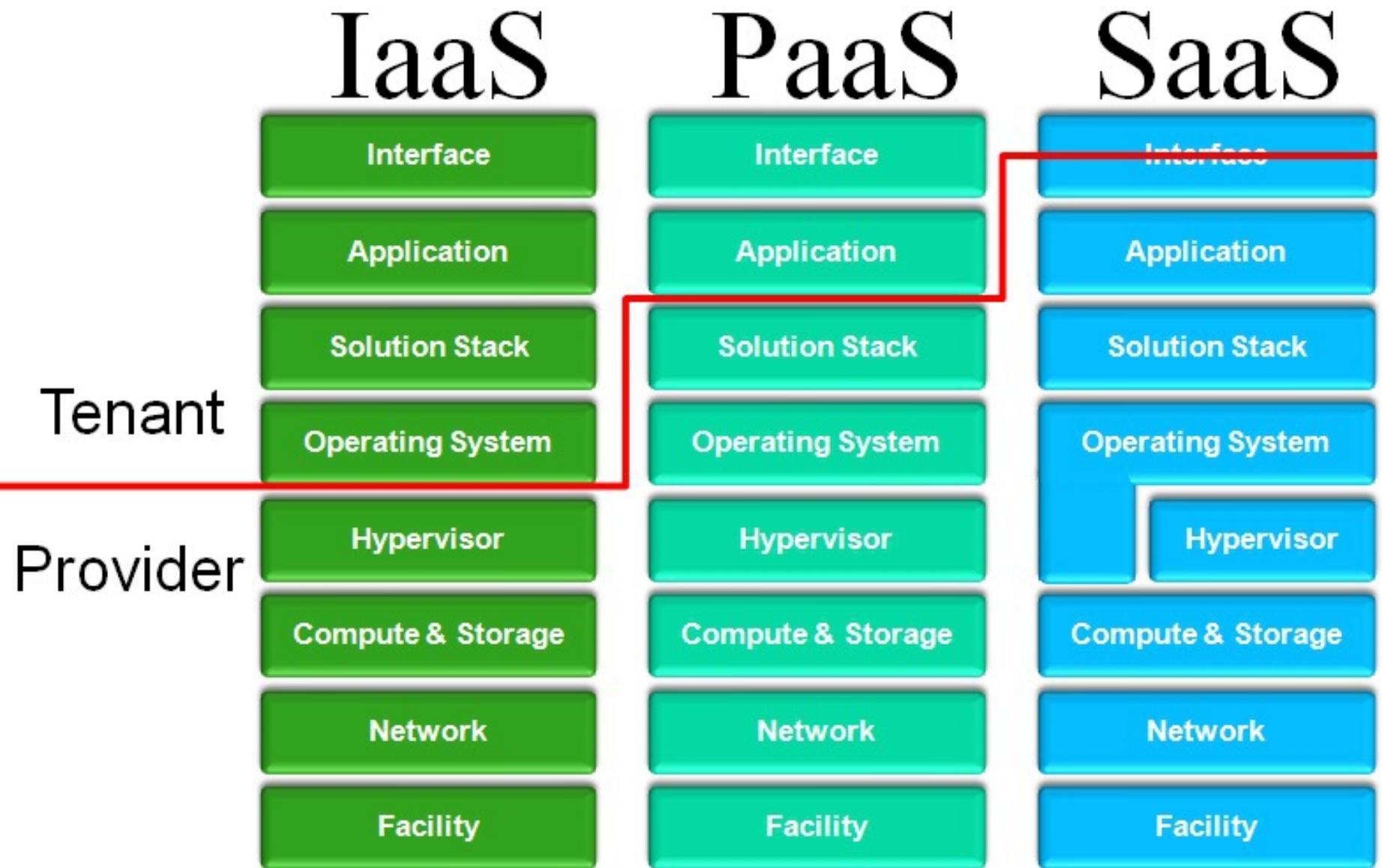


# Cloud Stack

- SaaS: the client is availing of a software solution on the cloud, delivered over the web
- PaaS: the client is availing of a set of tools and services designed to make coding and deploying those applications quick and efficient
- IaaS: the client is availing of computing power, hardware and software, such as – servers, storage, networks or operating systems

Note: the differences between these categories of cloud computing, especially PaaS and IaaS, is become blurred in recent years, and will continue to do so.

# Cloud Stack



# 1. IaaS

Infrastructure as a Service

Computing Infrastructure

# Infrastructure as a Service (IaaS)

- Infrastructure as a Service (IaaS): provision **processing**, **storage**, **networks**, (optionally) **operating systems**, and **other fundamental computing resources**, where the consumer can deploy and run arbitrary software, including an operating system and applications, as an on-demand service.

## Infrastructure as a Service

- Servers, Storage, Networks, Data Centres



# Features of IaaS

IaaS is a rapidly developing field, but is generally accepted as complying with the following;

- Resources are distributed as a service
- Allows for **dynamic scaling**
- Has a variable cost, **utility pricing** model
- Generally includes multiple users on a single piece of hardware (**multi-tenancy**)

There are a plethora of IaaS providers from the largest Cloud players like Amazon Web Services and Rackspace to more boutique regional players.

# Where IaaS Makes Sense

Situations that are particularly suitable for Cloud infrastructure include:

- Where demand is very volatile – any time there are significant spikes and troughs in terms of demand on the infrastructure
- For new organizations without the capital to invest in hardware, or where there is pressure on the organization to limit capital expenditure and to move to operating expenditure.
- Where the organization is growing rapidly and scaling hardware would be problematic
- For specific line of business, trial or temporary infrastructural needs

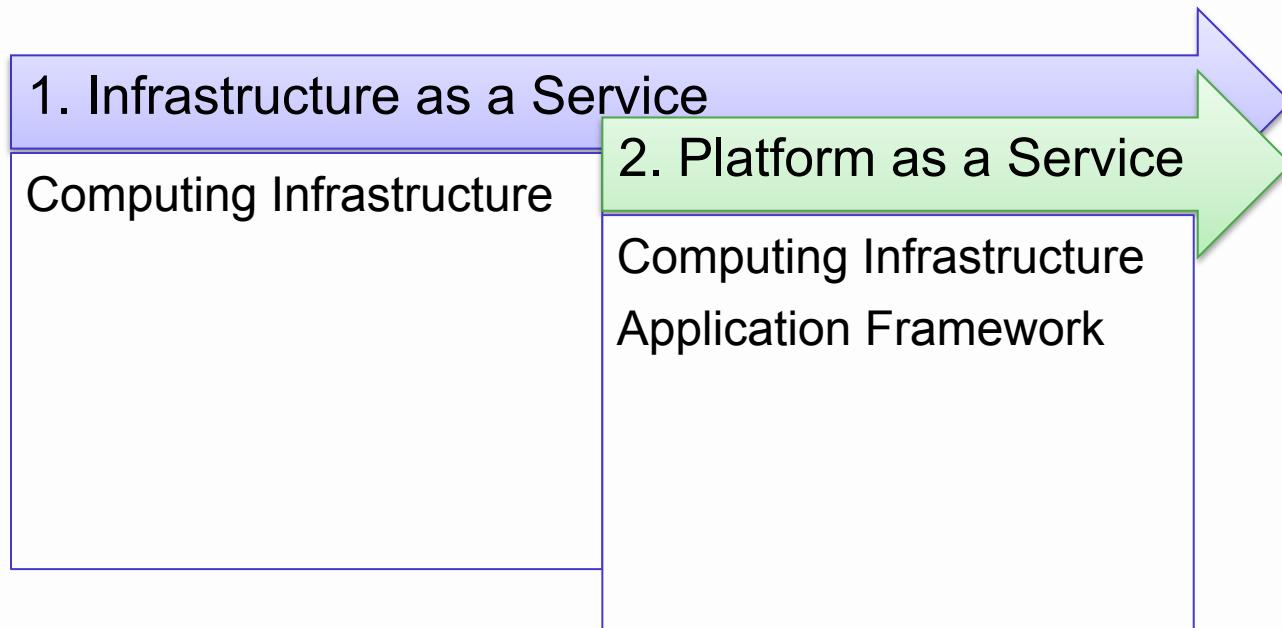
# Where IaaS doesn't Makes Sense

Despite its obvious advantages, there are situations where its limitations may be problematic, such as

- Where **regulatory compliance** makes the offshoring or outsourcing of data storage and processing difficult
- Where the **highest levels of performance are required**, and on-premise or dedicated hosted infrastructure has the capacity to meet the organization's needs

See Case Study on Iaas: **Lect 3 –Case Studies.doc**

## 2. PaaS



# Platform as a Service (PaaS)

- Platform-as-a-service in the cloud is defined as a **set of software and product development tools hosted on the provider's infrastructure**.
- Developers create applications on the provider's platform over the Internet.
- PaaS can be defined as a computing platform that allows the creation of web applications quickly and easily and without the complexity of buying and maintaining the software and infrastructure underneath it.

Warning: Some providers will not allow software created by their customers to be moved off the provider's platform.

# PaaS

There are differing opinions on what constitutes PaaS but some basic characteristics include:

- Services to **develop, test, deploy, host and maintain applications** in the same integrated development environment.
- **Multi-tenant architecture** where multiple concurrent users utilize the same development application.
- **Built in scalability** of deployed software including load balancing and failover.
- **Integration with web services and databases** via common standards
- **Support for development team collaboration** – some PaaS solutions include project planning and communication tools
- **Tools to handle billing and subscription management**

# Flavours of PaaS

PaaS, which is similar in many ways to Infrastructure as a Service, is differentiated from IaaS by the **addition of value added services** and comes in two distinct flavours;

1. A collaborative platform for software development, focused on workflow management regardless of the data source being used for the application.
  - An example of this approach would be Heroku, a PaaS that utilizes the Ruby on Rails development language.
2. A platform that allows for the creation of software utilizing proprietary data from an application.
  - This sort of PaaS can be seen as a method to create applications with a common data form or type. An example of this sort of platform would be Force.com, a PaaS from Salesforce.com which is used almost exclusively to develop applications that work with the Salesforce.com CRM

# Where PaaS Makes Sense

- PaaS is especially useful in any situation where **multiple developers** will be working on a development project or where other **external parties need to interact with the development process**.
- It is proving very popular for those who have an existing data source, for example sales information from a customer relationship management tool, and want **to create applications which leverage that data**.
- Finally PaaS is useful where developers wish to **automate testing and deployment services**.
  - The popularity of agile software development, a group of software development methodologies based on iterative and incremental development, will also increase the uptake of PaaS as it eases the difficulties around rapid development and iteration of software.

# *Where PaaS May Not be the Best Option*

PaaS is expected to become the predominant approach for software development.

That said, there are certain situations where PaaS may not be ideal, examples include;

- Where the application needs to be **highly portable** in terms of where it is hosted.
- Where **proprietary languages** or approaches would impact on the development process.
- Where a proprietary language would hinder later moves to another provider – concerns about **vendor lock-in**.
- Where **application performance** requires customization of the underlying hardware and software.

## Examples:

- Google App Engine:  
<http://code.google.com/appengine/>
  - Also powering Facebook Apps engine
- Microsoft Azure Services (Windows azures and SQL azures): <http://www.microsoft.com/windowsazure/> and
- the Force.com platform to extend an existing application: <http://www.force.com/>.

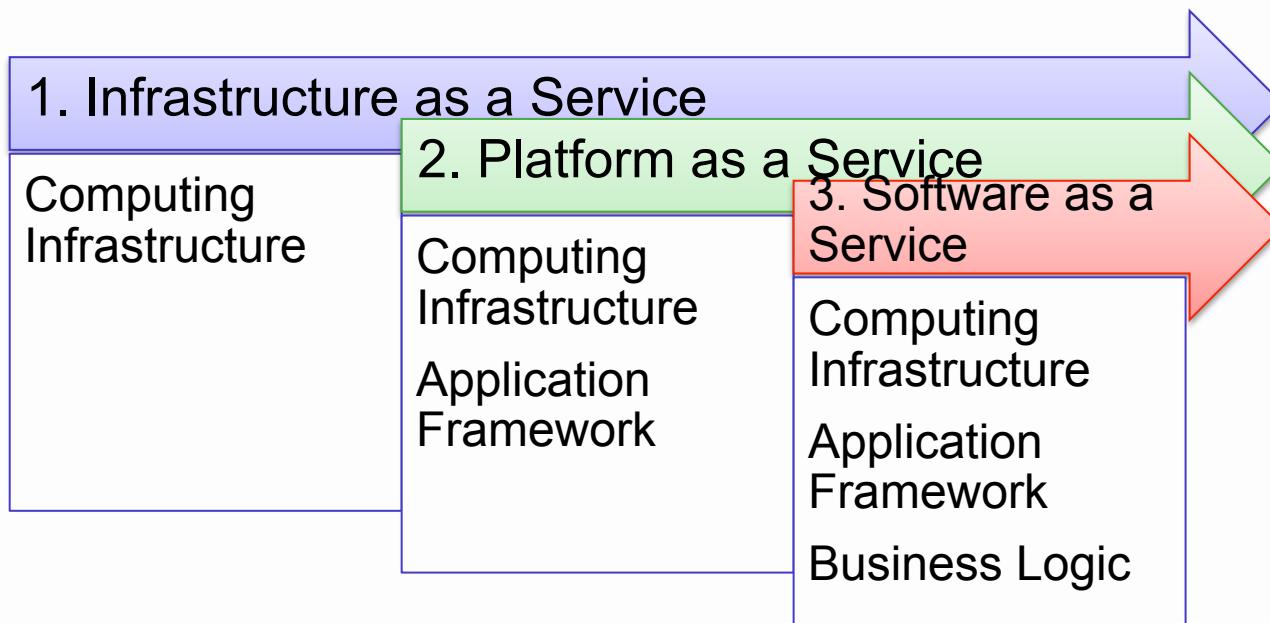
### Platform as a Service

- Development Platform, Solution Stack



See Case Study on Paas: **Lect 3 –Case Studies.doc**

# 3. SaaS



# Software As A Service (SaaS)

- **Concept:** Instead of a software vendor selling a software license that the client then implements and maintains in its own data center, the vendor (or, more properly, the service provider) hosts the system on its own computers in its own data center and **provides access to the system on a subscription basis**.
- Software on-demand turns software from a license sale to a subscription service.

## Software as a Service

- Turnkey software solutions



CRM, HRM, financials



gmail, picasa  
google earth . . .

Microsoft®  
Online Services

# SaaS

- SaaS is a rapidly growing market and expected to continue with ongoing double digit growth.
- This rapid growth indicates that SaaS will soon become commonplace within every organization and hence it is important that buyers and users of technology understand what SaaS is and where it is suitable.
- PwC's latest Global 100 Software Leaders Report data (2014) shows that the top companies in the industry recorded a modest 5% increase in total software revenues for 2012, reaching US\$255 billion, but Software-as-a-Service (SaaS) revenues in the top 100 increased by 60% to US\$20 billion during the same time period as the software industry has continued a consistent and growing shift towards SaaS

# SaaS

- In the software-as-a-service cloud model, the vendor supplies the hardware infrastructure, the software product and interacts with the user through a front-end portal.
- There are two variations in the model for software as a service today:
  - the service provider may host a separate system for each customer (the "single tenant" model), or,
  - the vendor may host multiple customers on the same instance of the system (the "multi-tenant" model).
- It is a relatively simple matter for most software vendors to deploy software as a service in a single tenant model.
- But only vendors that have specifically designed their systems from the ground up to host multiple clients on a single instance can deliver software as a service under the multi-tenant model.

# Software As A Service (SaaS)

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SaaS solutions must include the following:

1. Web access to commercial software
2. Software is managed from a central location
3. Software delivered in a “one to many” model
4. Users not required to handle software upgrades and patches
5. Application Programming Interfaces (APIs) allow for integration between different pieces of software

# Where SaaS Makes Sense

There are particular solutions which are considered prime candidate for an initial move to SaaS:

1. “Vanilla” offerings where the solution is largely undifferentiated.
  - A good example would include email where competitors use the same software because this fundamental technology is a requirement for doing business, but does not itself confer an competitive advantage.
2. Applications that have a significant need for web or mobile access.
  - If deployed in the cloud, its accessible from anywhere.

# Where SaaS Makes Sense

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3. Software that is only to be used for a **short term need**.
  - An example would be collaboration software for a specific project
4. Software where **demand spikes significantly**,
  - for example tax or billing software used once a month

E-mail, financial management, customer service and expense management have all got good uptake via SaaS.

# *Where SaaS May Not be the Best Option*

Examples where SaaS may not be appropriate include:

- Applications where **extremely fast processing of real time** data is required
- Applications where **legislation** or other regulation does not permit data being hosted externally

See Case Study on Saas: **Lect 3 –Case Studies.doc**

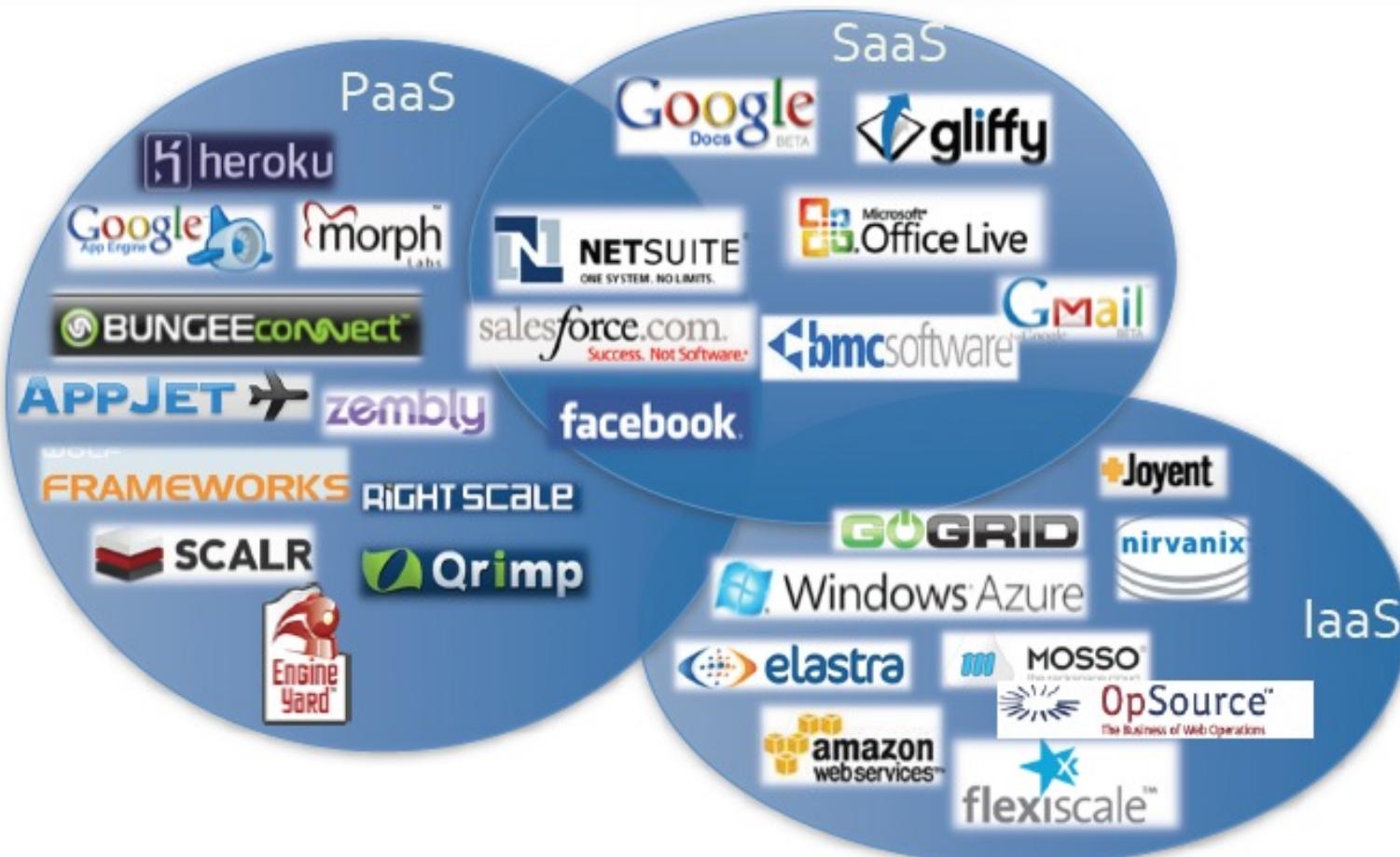
# SaaS examples

- SaaS is a very broad market with hundreds of providers.

Examples:

- Salesforce.com offers complete sales force automation and CRM functionality for a flat per-user, per-month fee of less than \$100.
- ADP: a long-time provider of payroll services;
- Netsuite: a complete ERP system offered as a service;
- Webex: provider of on-demand web conferencing.
- Googles many serivces: Gmail, google earth, google translate, YouTube, google calendar, google groups, google desktop, google screensaver, etc.,

# Some Cloud providers



# Cloud Computing in Ireland

Ref: IRELAND'S  
COMPETITIVENESS  
& JOBS OPPORTUNITY:  
CLOUD COMPUTING. Microsoft Ireland, 2011

Based on research carried out by Goodbody for Microsoft Ireland.

# Key findings . . .

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- Cloud Computing is a major evolving industry that will revolutionise how businesses and public sector organisations run their operations and deliver products and services.
- *“The Government believes that between our climate, skills base, telecoms connectivity and existing strengths in ICT, we have the potential to reap substantial benefits in terms of jobs and growth from the global expansion of this sector”* (cloud computing), Irish Independent, 2012.
- *“Dublin boasts one of the densest clusters of data centres in Europe. The area surrounding Ireland’s capital city already has as many as 30 large-scale data centre operations, including global operations run by Google, Microsoft and Amazon.”* IDA, 2014

# Benefits to Ireland

- By far the greatest benefit of Cloud Computing is as a source of exports, growth and jobs for the Irish economy.
- A significant portion of existing IT activity will migrate to the Cloud because of its cost and quality advantages.
- Ireland has a **vigorous emerging** Cloud Computing industry.
- The total cost of information technology ("IT") for Irish businesses and public sector > **€4bn**. Goodbody has estimated Irish businesses and public sector bodies would benefit from cost savings of approximately **€0.5bn** per annum if Cloud Computing is adopted quickly by Irish IT users.

# Benefits to Ireland

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- Cloud Computing will mean that even the smallest user of IT will have access to IT services of the highest quality.
  - This could result in the formation of up to 2,000 additional non-IT small and medium sized businesses in Ireland over the short to medium term.
  - These businesses could increase employment in the economy by 11,000.

# Multi-nationals in IRELAND active in the cloud

FIGURE 5.2: Multinationals active in the Cloud

	Infrastructure as a Service	Platform as a Service	Software as a Service
<b>Microsoft</b>	✓	✓	✓
<b>EMC<sup>2</sup></b> where information lives	✓		
<b>hp</b> ITSM	✓	✓	
<b>amazon.com</b>	✓		
<b>Google</b>		✓	✓
<b>sage</b>			✓
<b>IBM</b>	✓		
<b>vmware</b>	✓		
<b>salesforce</b>		✓	✓
<b>MySQL</b>			✓
<b>Sun</b>			✓
<b>CITRIX</b>			✓
<b>SuccessFactors</b> Business Execution Software			✓

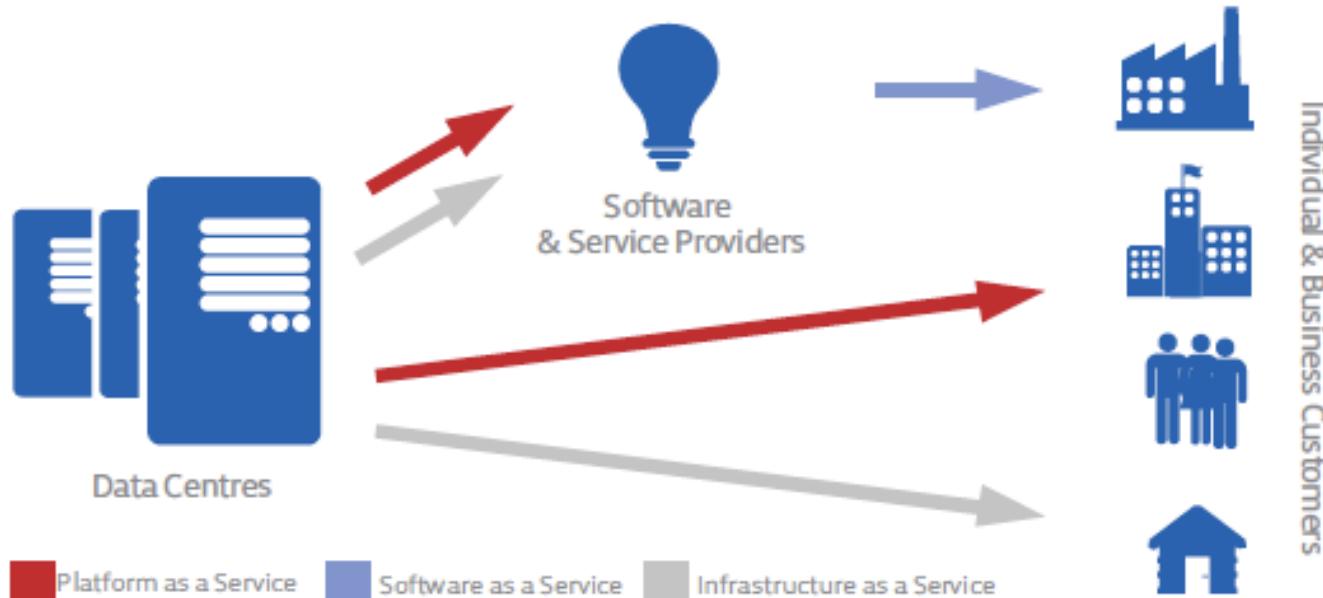
Source: Source IDA 2010

# Other cloud providers in Ireland

In addition, innovative Irish firms are entering these new markets and developing Software as Service offerings:

- **Clavis Technology** who have developed a specialist utility to validate data as it is captured or sourced;
- **HR Locker** which provides large and small businesses with tools to manage their human resources; and,
- **Lucey Technology** who have developed online payment and collaborative working offerings.

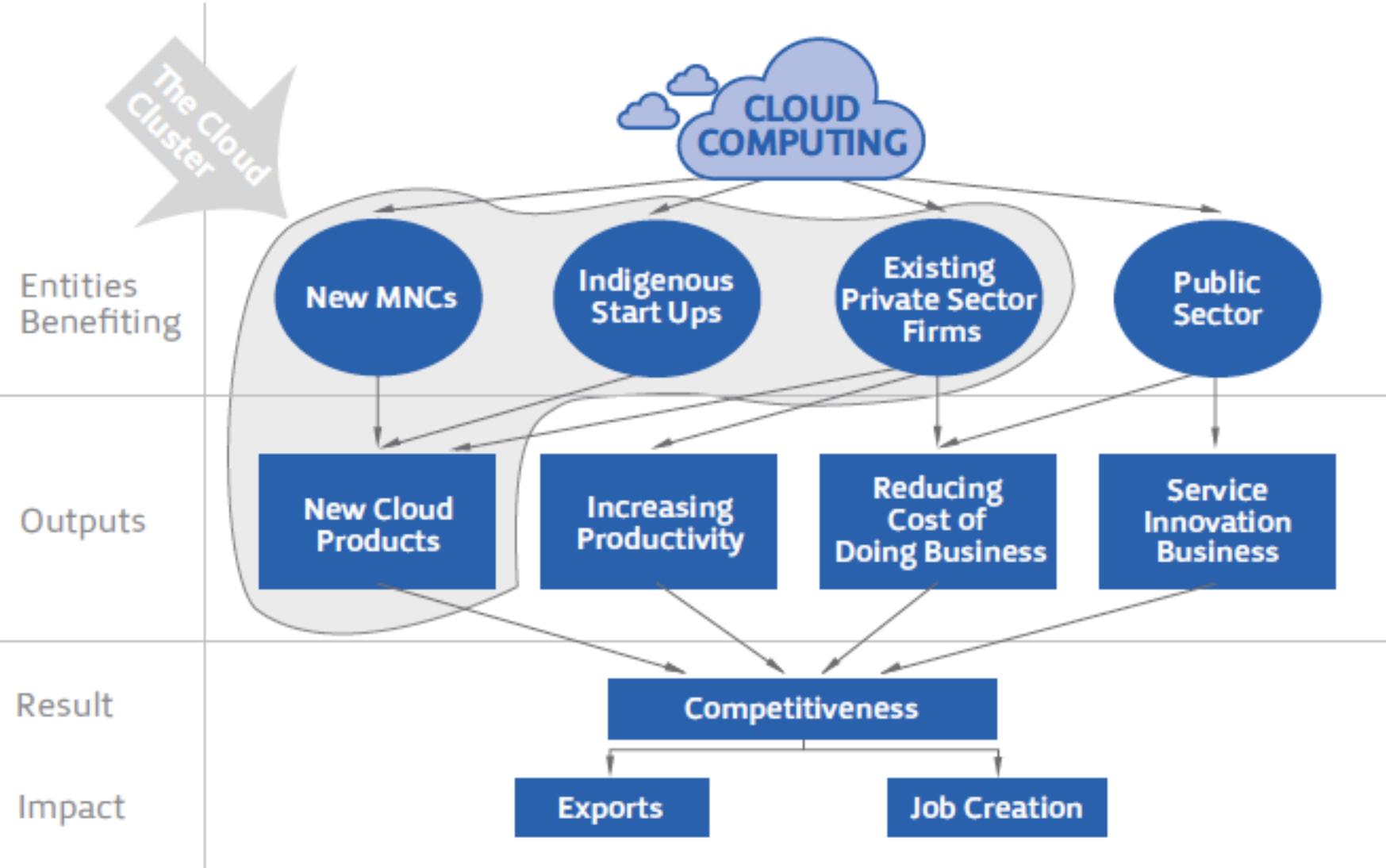
FIGURE 5.1: Overview of Cloud Computing Participants



# Cloud providers in Ireland

- A significant number of indigenous software firms are active in Cloud Computing.
- In particular there is a large and active community of start ups developing new Cloud Computing software and services.
  - Many of these benefit from Microsoft's BizSpark Network.
  - BizSpark is a global initiative operated by Microsoft that nurtures next-generation start-ups. BizSpark members receive free technology services in the early years of operation.
  - **Ireland is host to the largest BizSpark community per capita outside the USA**, with over 400 firms participating. A high proportion of this community are developing Cloud Computing products.

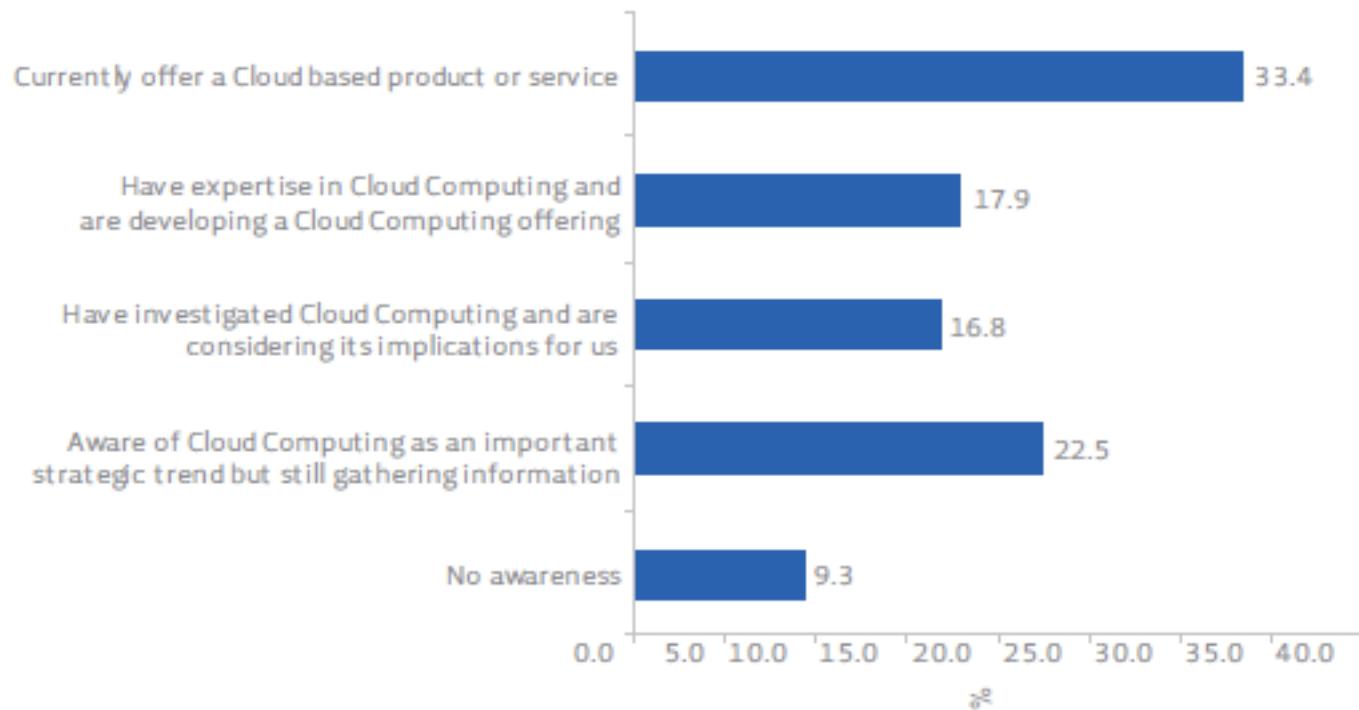
FIGURE 2.4: Role of Cloud Computing in Economic Development



Source: Goodbody Economic Consultants

# Awareness of Cloud Computing in Ireland

FIGURE 5.3: Knowledge of Cloud Computing among Irish ICT Firms



Source: Goodbody Economic Consultants

# Policy Priorities for Cloud Computing in Ireland

1. Broadband Infrastructure within Ireland
2. International Connectivity
  - Access to Tier 1 high-speed, low-latency networks to the US, UK and EU has been pivotal to Ireland's Cloud success story.
3. Privacy and Data Protection
  - Data Protection legislation in Ireland is now one of the most advanced in Europe and highly protective of company data.
4. Security and Access to Data
  - Tighter legislation on who owns the data, and prevention of vendor lock-in

See [here](#) for an update on what the government has been doing, published in April 2012

# Case study – new services enabled by cloud services: National Library of Ireland

## CHALLENGE

The National Library of Ireland is home to some of Ireland's greatest treasures and among its eight million items are very rare and delicate documents. The NLI has a global reputation, has works of historical relevance that are known the world over but could only be examined by visitors who came to the library. The Library faces a number of challenges when organising exhibits and displays:

- Exhibition space tends to be limited and that means that only 26 artefacts can be displayed in its current exhibition.
- At times, artefacts can be too fragile or large be placed on public display in exhibition cases.
- It also was aware of the important role that Irish history and culture plays in building and maintaining Ireland's reputation globally and attracting cultural tourism. The library has a large number of international visitors each year and growing numbers of queries from international students and people from both within and outside Ireland who are interested in Irish culture and history. The library wanted to increase access to the documents, manuscripts and materials without compromising their quality while attracting new audiences.

# Case study: National Library of Ireland

## SOLUTION

The Library looked at how it could use new and emerging channels and technology to increase access to the library's eight million items and started a project that embraced the web and new types of display solutions, such as surface technology.

The Library used a number of technological advances to design a unique exhibition, **Discover Your National Library: Explore, Reflect, Connect**. For example, it used the Microsoft Surface 'discovery table', a computer which responds to natural hand gestures, and which holds every object in the exhibition (and many which are not currently in the exhibition but will be in the future through a series of revolving temporary exhibits) as the exhibition's central repository. The images are tagged in such a way that if the visitor finds an item they are particularly interested in, the technology automatically links them to other similar items likely to be of interest.

In addition, the library, who wanted to broaden the reach of its exhibits to visitors who are unable to go to the Library, has also made the interactive tables available online on [www.nli.ie/discover](http://www.nli.ie/discover). Any consumers who have a touch screen computer can enjoy the same interactive experience that visitors to the library do. Those without touch screen capability, can also view the images in detail online at [www.nli.ie/discover](http://www.nli.ie/discover).

# Case study: National Library of Ireland

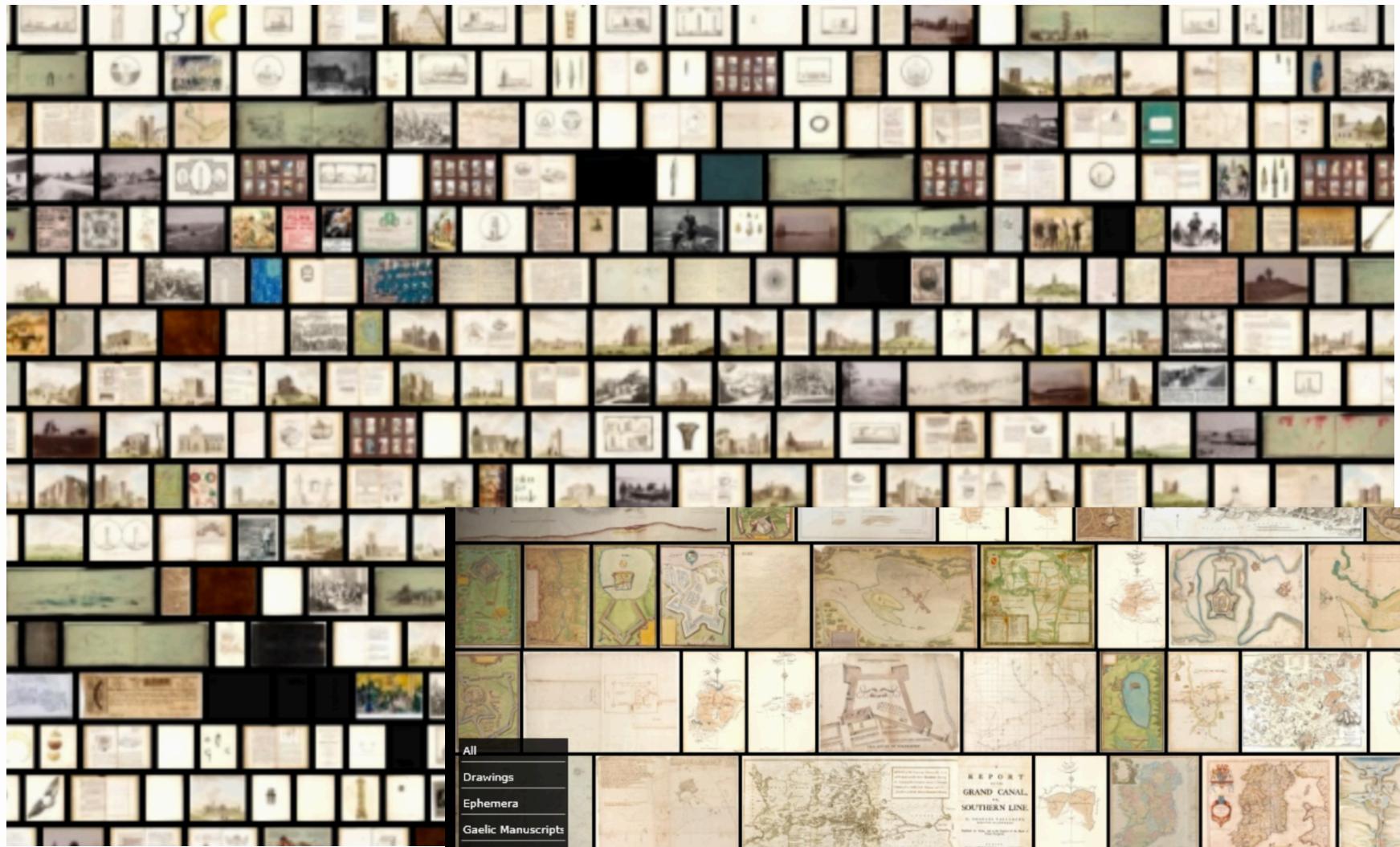
## OUTCOME

As a result of the project, the library has now completely transformed how it shares its collection with people and its target audiences have expanded significantly as it is now actively seeking to engage with a wide variety of virtual visitors across the globe.

Currently, the Microsoft Surface tables display more than [seven hundred rare documents](#), some of which are either too fragile and large to be placed on public display in exhibition cases. [Visitors can now view images of objects from the collections in amazing detail](#) that has hitherto been possible for only a limited number of researchers, academics and other specialists.

During its first six weeks alone, the Discover website received 1,000 unique visits. Reviews of the exhibition have acknowledged that the NLI has managed to introduce its collection to a wider public, and that fragile and delicate documents can be easily found, examined, magnified and manipulated as never before.

<http://www.nli.ie/discover/>



All

Drawings

Ephemera

Gaelic Manuscripts

Heraldry & Genealogy

Manuscripts

Maps

Newspapers &  
Periodicals

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# Cloud Computing – Legal Aspects

# Service Level Agreement (SLA)

SLA sets out the service level which overrides any publicity material or web-site material.

What to watch out for:

1. Warranty – a guarantee of the service to be provided
2. Liability – who bears the cost if something goes wrong
3. Data Protection – how is data protected

This section will also look at IT Forensics in the cloud

# SLA - Warranty

Many providers exclude almost all warranties regarding:

- Performance
- Functionality
- Reliability
- Availability

Example: Google Apps terms of Service Warranty:

- “Google... do[es] **not warrant** that (i) Google services will meet your requirements, (ii) Google Services will be uninterrupted, timely, secure, or error free, (iii) the results....will be accurate or reliable.....”.

# SLA: Liability

- Outages do occur
  - Amazon EBS (data storage) center in the US was interrupted for 4-days in 2011.
- In theory, an external party (the Provider) should be liable for service failure.
- In practice, no guarantee is given of financial compensation for business disruption.

There is a Cap on or Exclusions of liability in many Cloud SLAs, which leave little scope for negotiation.

Terms of Service  
Google Apps  
Limitation/Exclusion of Liability

**"Limitation on amount of Liability:** Neither party may be held liable under this agreement for more than the amount paid by Customer to Google during the twelve months prior to the event giving rise to liability".

Or

"...Google ..... **shall not** be liable to you for any direct, indirect, incidental, special, consequential or exemplary damages....resulting from any...matter relating to Google services".

# Compensation

Compensation “in kind” for loss of uptime – Amazon and Google SLA’s offer:

- Reduction in future service charge
- Service credits
- Free days service

i.e. “tie-ins”.

- **Exclusive jurisdiction** – any legal action must be taken abroad, often in United States.
- **Result:** the Customer largely bears the risk!

# BEST PROTECTION IN CHOOSING A CLOUD PROVIDER:

- Good track record
- Commitment to remain in the cloud computing market
- Ongoing **reputation** to protect

# Irish Data Protection Act, 1988

- **Data Controllers** (i.e. those storing **personal data**) are required to process data in compliance with the **Data Protection Act, 1988**
  - Responsible for implementing Appropriate measures to safeguard data, i.e. restrictions on access, disclosure and storage
- Cloud providers are generally **data processors**
- Responsibility to process data under the DPA cannot be sub-contracted to Cloud provider
- Data controllers are **liable for the breaches** of the data processor (i.e. the cloud provider).

# Irish Data Protection Act, 1988

- DP legislation **prevents** the transfer of personal data **outside the EEA** unless the laws of the recipient country provide adequate data privacy protection;
  - EEA - European Economic Area
  - Switzerland, Argentina and Channel Islands also approved by EU
  - Canada and Australia – only certain types of data transfers allowed, e.g. airline passenger data
  - United States: **Safe Harbor**, a Voluntary Code of Practice of US Department of Commerce.
- SLA may require the Customer to ensure it has the **consent** of data subjects to any transfer outside EU/EEA;

Amazon offers option of storage and processing of data in EEA only at a higher price.

# Data Security

It's important to ensure:

- Contract clarifies data is owned by Customer.
- Data stored in highly secure data centres
  - Reliance on Cloud Provider - loss of control
- Technical and Commercial **Due Diligence**
  - Is the Data backed up?
  - Is there a disaster recovery plan?
  - Is your data stored separately?

# Data Security

- If Customer wants to move to alternative cloud supplier or move data back in-house can it easily transfer data from the Cloud?
  - Cost and time-line of data migration should be set out in the SLA.
  - Obstacles to transfer data from Cloud:
    - Lack of a standard for virtual machine portability
    - Format of data
    - Source cloud may be technically incompatible with proposed destination cloud
    - Reliance on external IT consultants for migration if no in-house expertise
- What if Cloud Provider goes bankrupt?
  - Code and information escrow (distribution of assets).

# Forensics

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Cloud computing is still in its infancy – **cloud forensics** is even more so.

The following slides will look at some of the outstanding issues:

# Forensics

## 1. Technical Challenges

- **Evidence segregation:** one essential characteristic of cloud computing is resource pooling where various resources are shared in multi-tenant environments. Forensic investigations require evidence segregation but due to the nature of the multi-tenant environment, it can be virtually impossible to identify which user was using a particular resource(s) at any given time.
- **Virtualization:** Virtualization is a key technology used to implement cloud services. However tools and procedures are yet to be developed for investigations in virtualized environment, i.e. hypervisor investigations. In cloud forensics, tools and procedures need to be developed to physically locate forensic data at a given timestamp, and physically trace forensic data at a given time period, taking into consideration the jurisdiction(s) of the physical locations.
- **Data Collection:** Collecting forensics data should follow procedures that preserve the integrity of data without breaching law(s) and regulation(s) under the jurisdiction(s) where data is collected, or compromising confidentiality of any other tenant(s) sharing the same resource(s). This is currently a seemingly impossible task given the potentially diverse geographic locations where data in the cloud is stored and how it is stored.

# Forensics

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## 2. Organisational Problems

- When the Cloud Service Provider (CSP) outsources services to other parties, the scope of investigation widens. Therefore there is a need for a well-defined organisational structure for each cloud organisation (both the CSP and customers) if forensic investigations are to be possible in the cloud.

# Forensics

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### 3. Legal Problems:

- **Multi-jurisdictions and multi-tenancy:** Regulations and agreements have to be developed in the legal dimension of cloud forensics, to ensure that forensic activities will not breach any laws or regulations under any jurisdiction(s) where the data resides.
- **Service Level Agreement (SLA):** SLA defines the terms of use between a pair of CSP and cloud customer. Terms regarding forensic investigations must be set out in order to facilitate effective forensic investigations.

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# Cloud Computing – a green technology?

# Impact of Cloud Computing on the Environment

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- 1. Less IT hardware required.** Cloud computing uses fewer servers, towers, monitors, and other hardware components to accomplish the same tasks.
- 2. Less IT hardware waste.** Toxic chemicals, carcinogens and heavy metals are all part of the make up of a computer and the more efficient we are the less overall waste.
- 3. Less energy consumed.** It takes far less natural resources and energy to run a handful of centralized data centers than running hundreds or thousands of individual networks that often do not use resources to their fullest. Cloud computing is the car-pooling of information processing.
- 4. Less space requirements.** With centralized locations for public cloud computing, large organizations no longer must dedicate large areas of physical space to house their own IT equipment. If every company reduced their required floor space by just 400 square feet, imagine the materials and associated energy savings for commercial construction.

# Carbon foot print

Figure 1: Comparison of Carbon Emissions of Cloud-Based vs. On-Premise Delivery of Three Microsoft Applications

## Microsoft Exchange

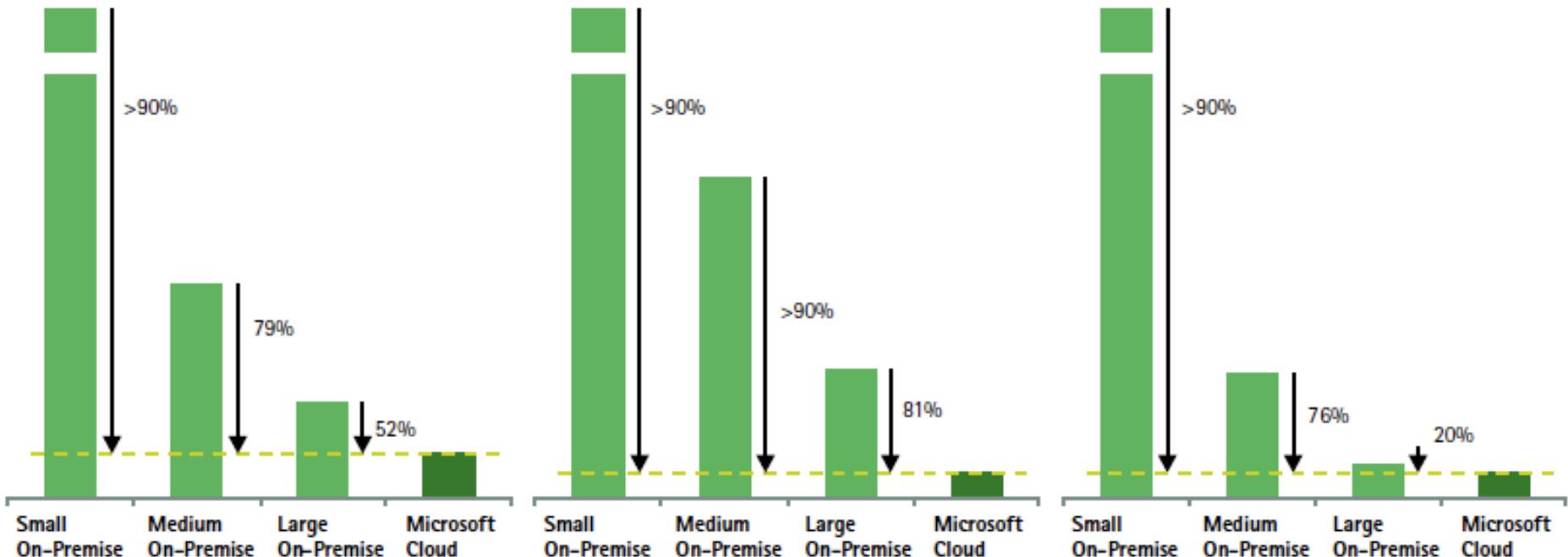
On-premise vs. Cloud Comparison,  
CO<sub>2</sub>e per user

## Microsoft Sharepoint

On-premise vs. Cloud Comparison,  
CO<sub>2</sub>e per user

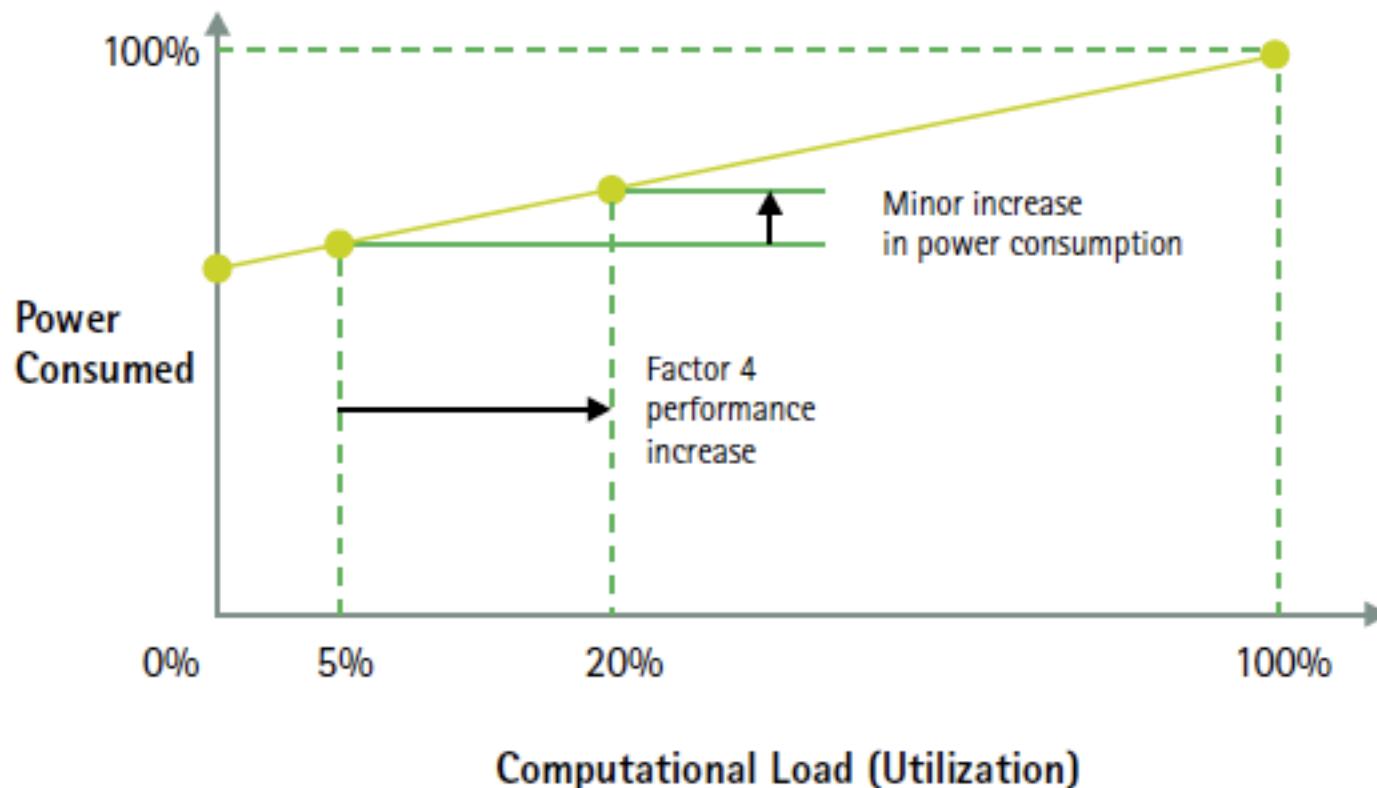
## Microsoft Dynamics CRM

On-premise vs. Cloud Comparison,  
CO<sub>2</sub>e per user



Ref: Cloud Computing and Sustainability: The Environmental Benefits of Moving to the Cloud, study conducted by Accenture for Microsoft.

# Power consumption



Ref: Cloud Computing and Sustainability: The Environmental Benefits of Moving to the Cloud, study conducted by Accenture for Microsoft.

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Some would say the equation  
is a little more complex . . . .

Ref: Make IT Green  
Cloud Computing and its  
Contribution to Climate Change,  
Greenpeace

# Green or Brown cloud ?

- Cloud providers are setting up data centers in locations providing the **cheapest energy**, typically coal-fired power stations, **largest source of greenhouse gas emissions**.
  - E.g. **Facebook** commissioned a data center in Oregon, Jan 2010, because of **cheap energy** from coal-fired power stations.
  - On the other hand, **Yahoo** opted for data center outside Buffalo, New York, that is powered by energy from a **hydroelectric power plant** - dramatically decreasing its carbon footprint.

Companies like Facebook, Google, and other large players in the cloud computing market must advocate for policy change at the local, national and international levels to ensure that, as their appetite for energy increases, so does the supply of renewable energy.

Many major cloud brands refuse to disclose their energy footprint

# Green or Brown cloud ?

- Cloud based services such as data, entertainment, news, delivered to devices in real time, **promotes greater use of person devices** such as iPad, smart phones and PC's.

Broadband uptake trebled to almost 900 million accounts over the same period, with **emissions doubling** over the entire telecoms infrastructure.

**Tablet ownership over time (2010-2013)**  
*% of American adults ages 18+ who own a tablet computer, over time.*



Source: Pew Research Center's Internet & American Life Project tracking surveys, May 2010 – May 2013. May 2013 data is from the Pew Research Center's Internet & American Life Project's April 17-May 19, 2013 Tracking Survey of 2,252 adults ages 18 and older. Interviews were conducted in English and Spanish and on landline and cell phones. The margin of error on the sample is +/- 2.3 percentage points.

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# Benefits and Challenges of Cloud Computing

# Cloud Benefits

## LOWER COSTS

- Google Mail 50-70% cheaper than on-site hosted email
- BT Virtual Data Centre 40% TCO savings
- Microsoft estimate 40-90% savings with BPOS

## CLEARER COSTS

- All in Monthly Fee
- Google Apps Premier Edition \$50 per user per year, Microsoft Exchange Online \$60 per user per year.
- Amazon EC2 \$70 to \$150 per server per month

## FASTER TIME TO MARKET

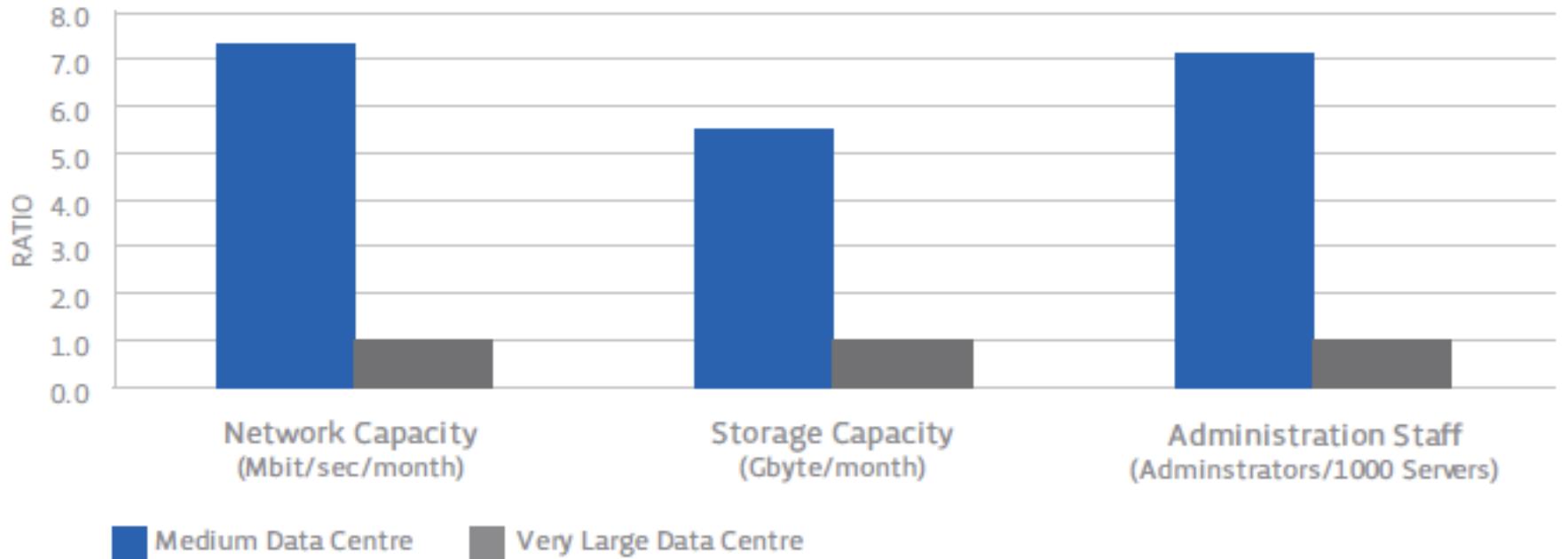
- Deployment in minutes and hours, instead of weeks and months
- Become a Business Enabler.

## RIGHT SIZED INFRASTRUCTURE

- Matching IT to business needs and size
- Scale Up and Down

# Cost Benefits . . .

FIGURE 3.1: Costs per Unit of Medium-Sized and Very Large Data Centres



Source: University of California Berkeley RAD Laboratory

If a firm currently uses 1,000 servers in an in-house data centre to meet its information technology needs, a large scale supplier of Infrastructure as a Service could provide a similar level of computing power at **one seventh** of the cost

# Cloud Challenges

- **Testing Risk (assessing provider)**
- **Data Location**
- **Data and Code Portability**
- **Data Loss**
- **Security Risk**
- **Vendor Viability**
- **Eco System**

Gartner's view  
of key  
challenges

# Summary

- Definitions of cloud computing – outsourcing
  - Shift from technology to service.
- Characteristics of cloud computing:
  - Elasticity, utility billing, multi-tenant, virtualised resources, management automation, self-service provisioning, 3<sup>rd</sup> part ownership, managed operations
- Public, Private and Hybrid clouds
- Cloud computing stack: IaaS, PaaS, SaaS
  - Services each offers, when to use each, when not to use each, examples & case studies

# Summary

- Cloud providers and Cloud Computing In Ireland
  - Benefits to Ireland, Case studies.
- Legal Aspects: Service Level Agreements, Ownerships, Liability, Warranties, Compensation, Data Security, IT Forensics
- Cloud Computing – a green or brown cloud
  - From the perspective of cloud providers and
  - From the perspective of the environmentalists.
- Overall Benefits and Challenges of Cloud Computing