Cloud Computing Fundamentals

Week One

School of Software

Faculty of Engineering and Information Technology

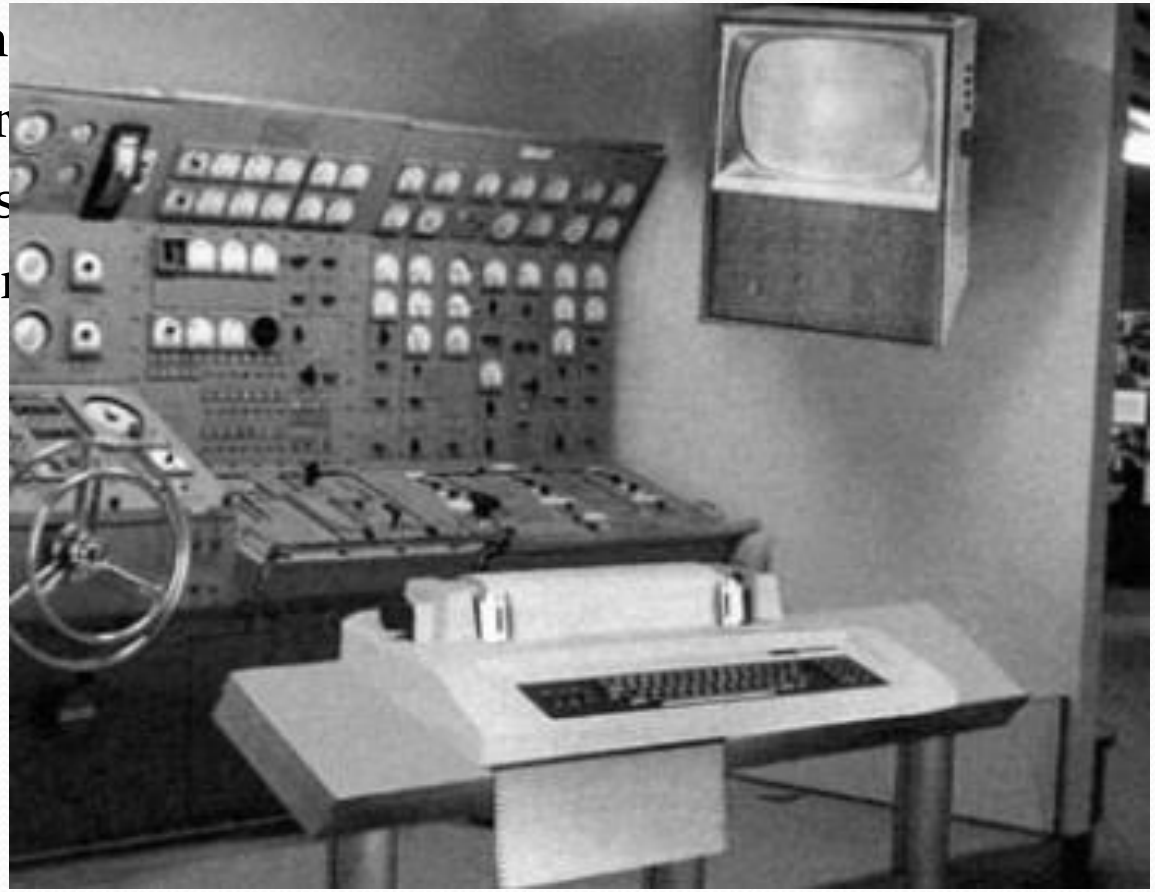
University of Technology Sydney

Learning Objectives

- Overview of the evolution of computing
- Understand the emergence of cloud computing
- Definition of cloud computing
- Understand the key parameters of cloud computing
- Understand cloud computing driving parameters

Evolution of Computing Hardware (1/3)

- Single stand-alone machine (1950's)
  - Big Bulky mach
  - Limited Memor
  - Limited Process
  - Extremely exper



"I think that there is a world market for maybe five computers" -- Thomas Watson, Chairman of IBM, 1943

Evolution of Computing Hardware (2/3)

- Commercial Mainframes (1960's)
  - Big "Frames" comprising of computing elements
  - Initially were develo
  - Time-Shared (virtua
  - Typical memory was
  - Typical processing p

"Where a calculator on the ENIAC is equipped with 18,000 vacuum tubes and weighs 30 tons, computers in the future may have only 1,000 vacuum tubes and weigh only 1.5 tons." -- *Popular Mechanics, 1949*

Evolution of Computing Hardware (3/3)

- Personal Computers (1980's)
  - Pioneered by IBM
  - Advancement in Microprocessors
  - Typical memory: 16 KB
    (256 KB in the powerful versions)
  - Typical Non-Volatile memory: 4 MB
  - Typical Processing Power 4 MHz – 8 MHz

Figure : An IBM PC

"640KB ought to be enough for anybody." -- *Attributed to Bill Gates, 1981, but believed to be an urban legend*

World Wide Web

- Implementing of the World Wide Web (1990's)
  - Building a network of computers
  - Standardization of networking technology (TCP/IP)
- Large scale adoption of the World Wide Web in 1990's

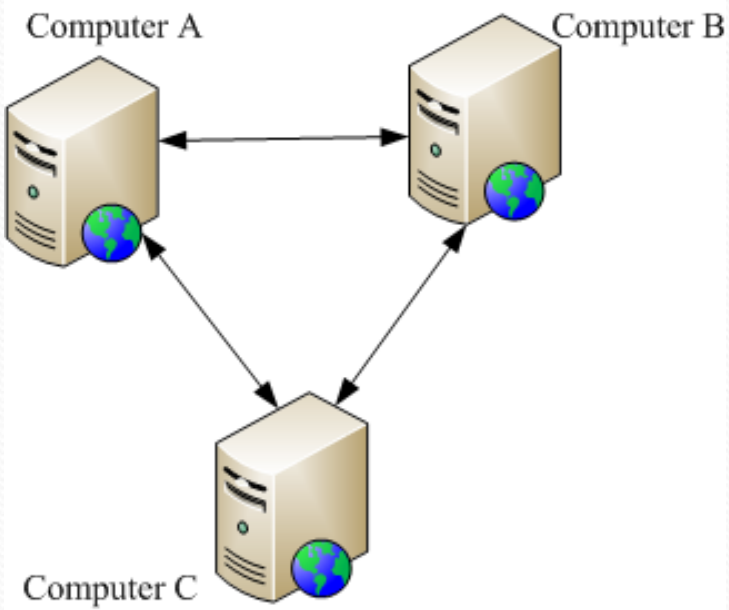


Figure: Interconnected Computers

Grid Computing (Late 1990's)

- Utilization of idle computing resources
- "*Knitting*" of autonomous computing resources
- Harnessing the power of the web for solving complex problems that cannot be solved by a single computer
- Geared towards scientific problem solving (geological sciences, medical sciences etc....)

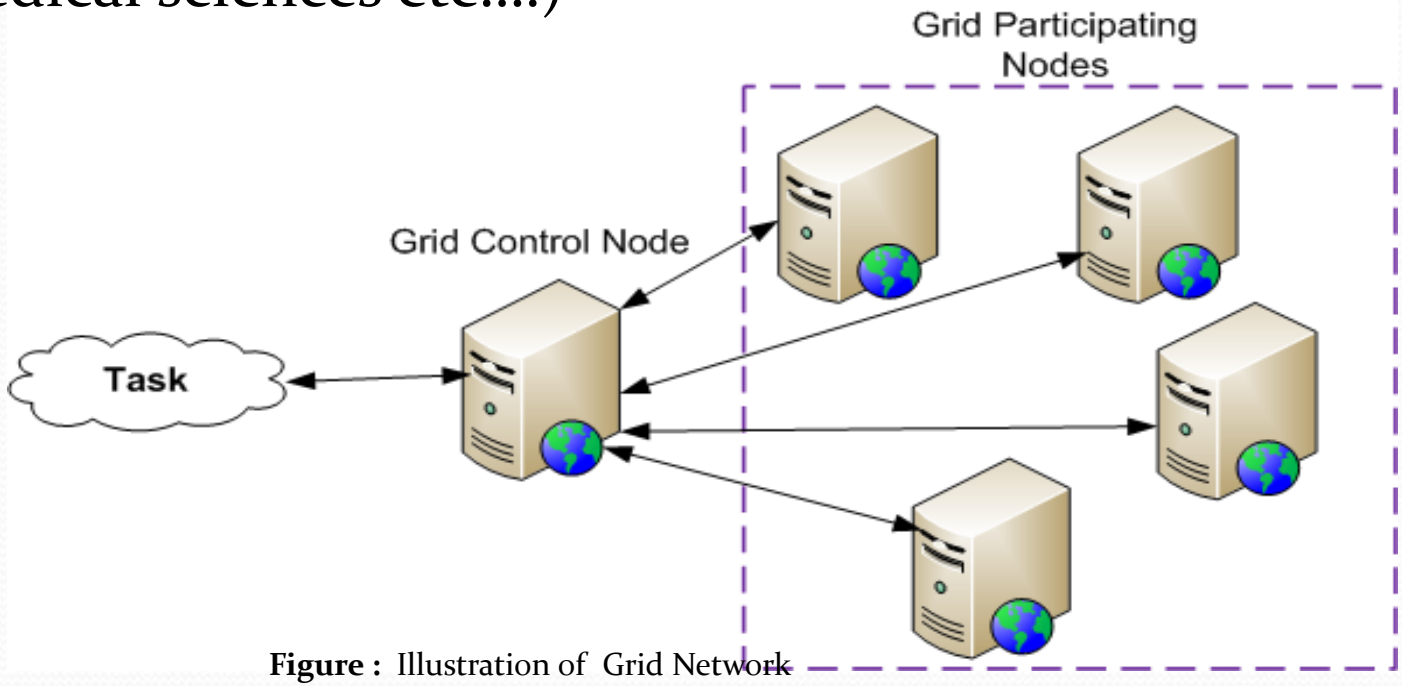


Figure : Illustration of Grid Network

Evolution in Computing Software

- Changes in the design philosophy for engineering computing software
- Process-Oriented Architecture
  - Programs are functionally decomposed into processes, that act upon shared data
  - Data structures are complex and large

Object-Oriented Architecture

- Reflection of the real world comprising of objects or entities
- An object is an encapsulation of a data structure, and the methods or operations to access those structures
- Objects communicate with each other by passing messages (which in turn may invoke other object)

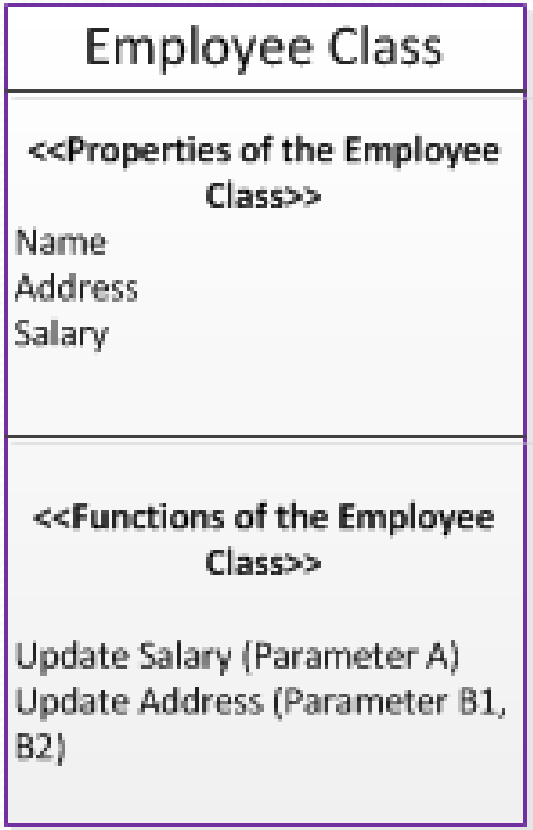


Figure : An example of class

Service Oriented Architectures

- The software application is construed as being organized of "*software services (components)*".
- A "software service" is a piece of code that provides a given (well defined) functionality (Example: "Authentication", "Registration", "Billing" etc…).
- A software service can be "*invoked*" to deliver its functionality
- Software service interfaces are based on public standards for interoperability.
- Promotes re-use of software services across a range of applications (Examples: Registration Component, Authentication Component, Billing Component etc… , and their use across a number of software applications such as Student Management Application, Staff Management Application, Bank Applications etc…)

Service Oriented Architectures

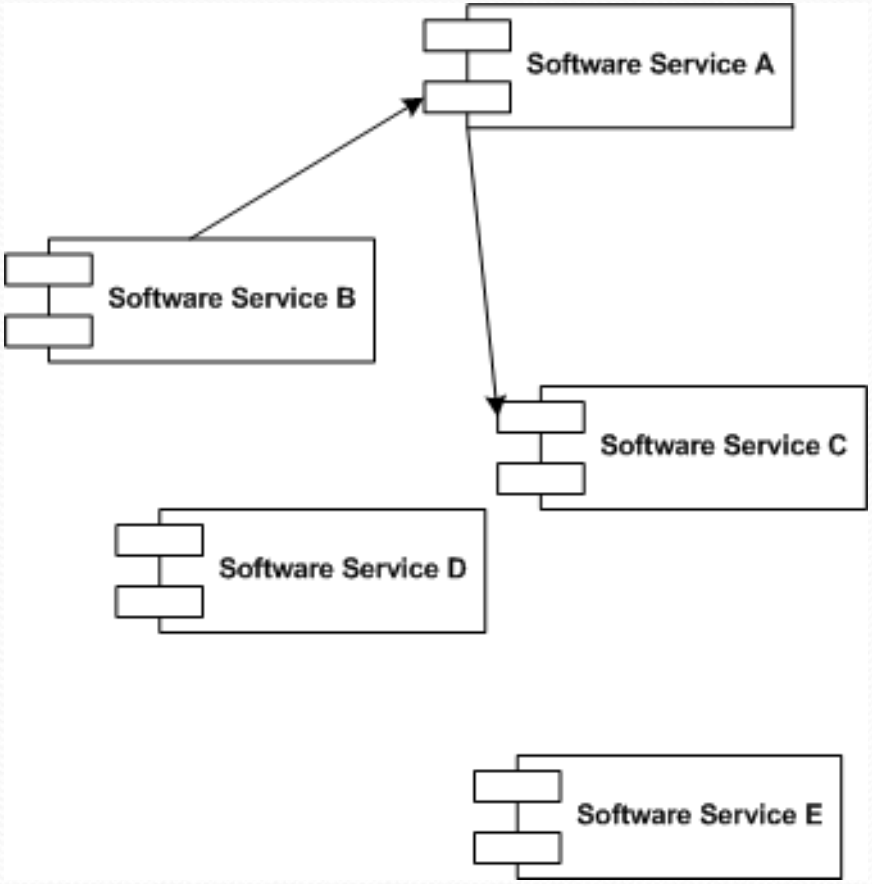
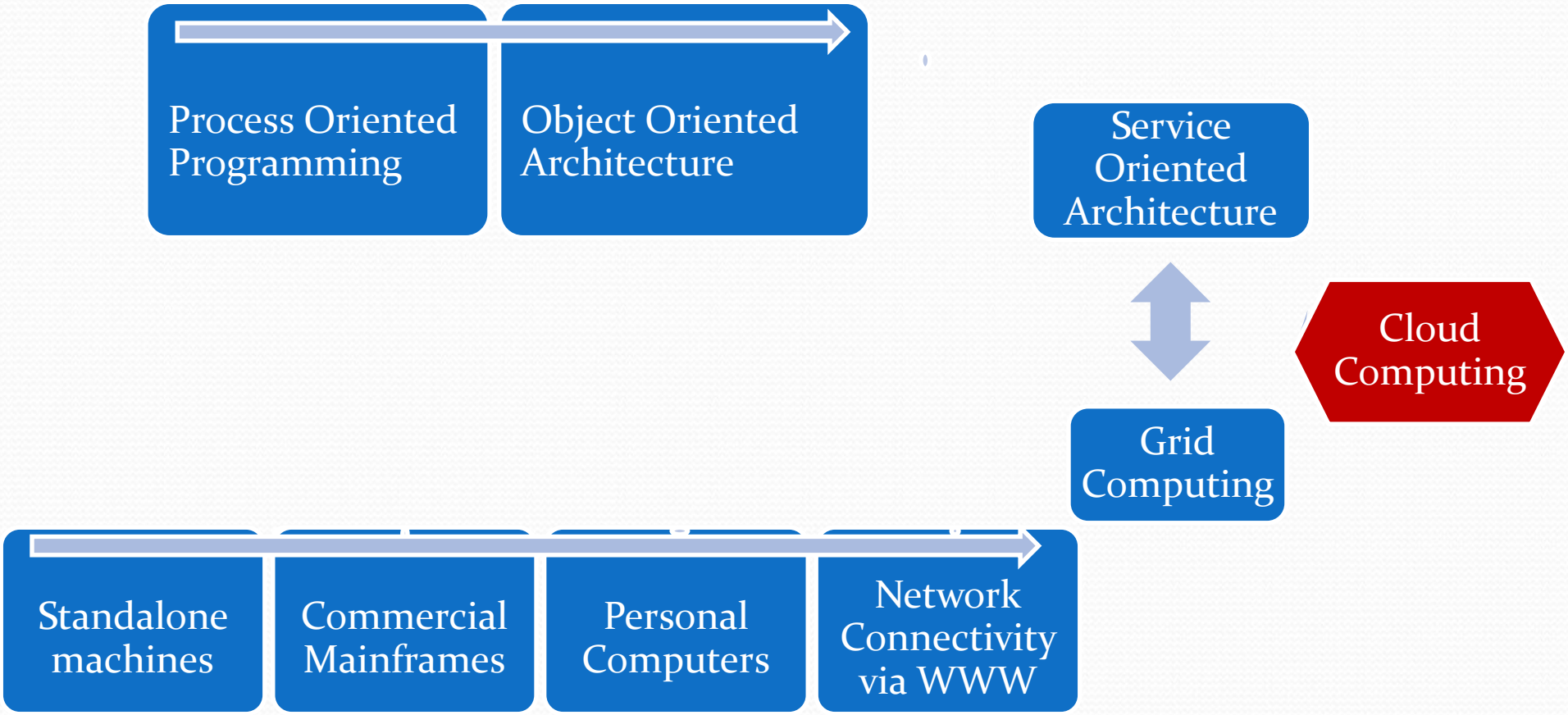


Figure : Illustration of software services invoking

Evolution of Cloud Computing

An Integrated View



Cloud Computing

The NIST Definition of Cloud Computing

"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".

Key aspects of the definition:

(a) Cloud providers own a large pool of computer resources
(b) Computing resources are offered "as-a-services"
(c) Computing resources can be dynamically scaled-up or vice-versa

Key parameters of Cloud Computing

(a) Pooled (computing) resources
(b) Elastic scaling of resources
(c) Virtualization of resources
(d) Pay-as-you-go (or) Metered resource usage
(e) Resource Delivery over the internet
(f) Automation of new resource deployment and de-provisioning

Pooling of Computing Resources

- Computing Resources (are pooled) by the (cloud) service provider, and made available to the requestors (cloud service requestors).
- Available on request to anyone without any (geographical) constraints

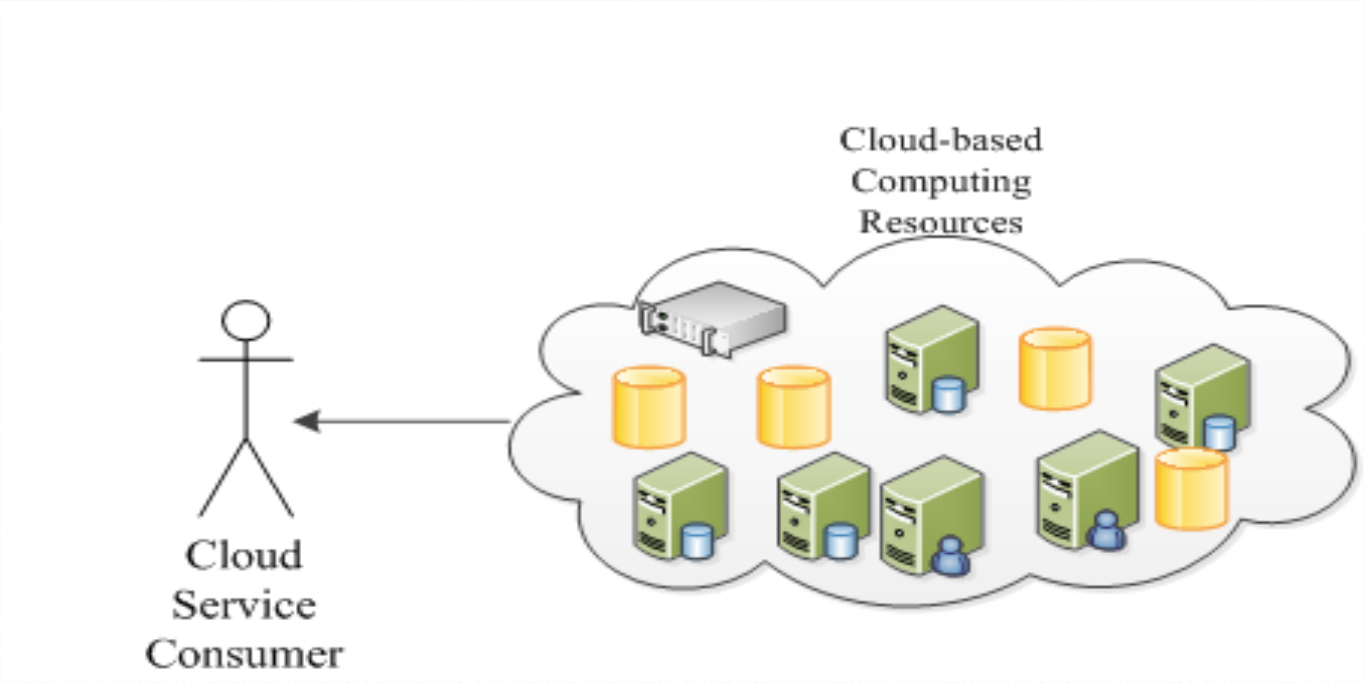


Figure : Illustration of pooling of computing resources

Elastic scaling of computing resources

- Applications require base level computing resources under normal circumstances
- They may require additional resources to handle abnormal circumstances (peak load)
- Elastic scaling of computing resources
  a) Cloud platforms offer dynamic scale-up or scale-down of computing resources
  b) Saves resources and time to handle peak demand
- What would be economic implications of (a) and (b) above for enterprises?

Elastic scaling of computing resources

- Move from investing in *Cap*ital *Ex*penses (CapEx) to *Op*erational *Ex*penses (OpEx)
  - No-upfront costs
  - Reduction in the actual value of Operational Expenses due to the economies of scale.

Virtualized computing resources

- Enables high utilization of the computing resources
- "*Slice-and-dice*" computing resources to create virtual resources
  - Virtual resources are provided to cloud consumer (on-the-fly)
- Virtualization is enabled through virtualization mechanisms such as hypervisors etc…
- Example (Virtual Servers):
  - Physical Servers can be partitioned to a number of "virtual servers"
  - Virtualization mechanisms ensure that each virtual server acts like a real server

Virtualized computing resources

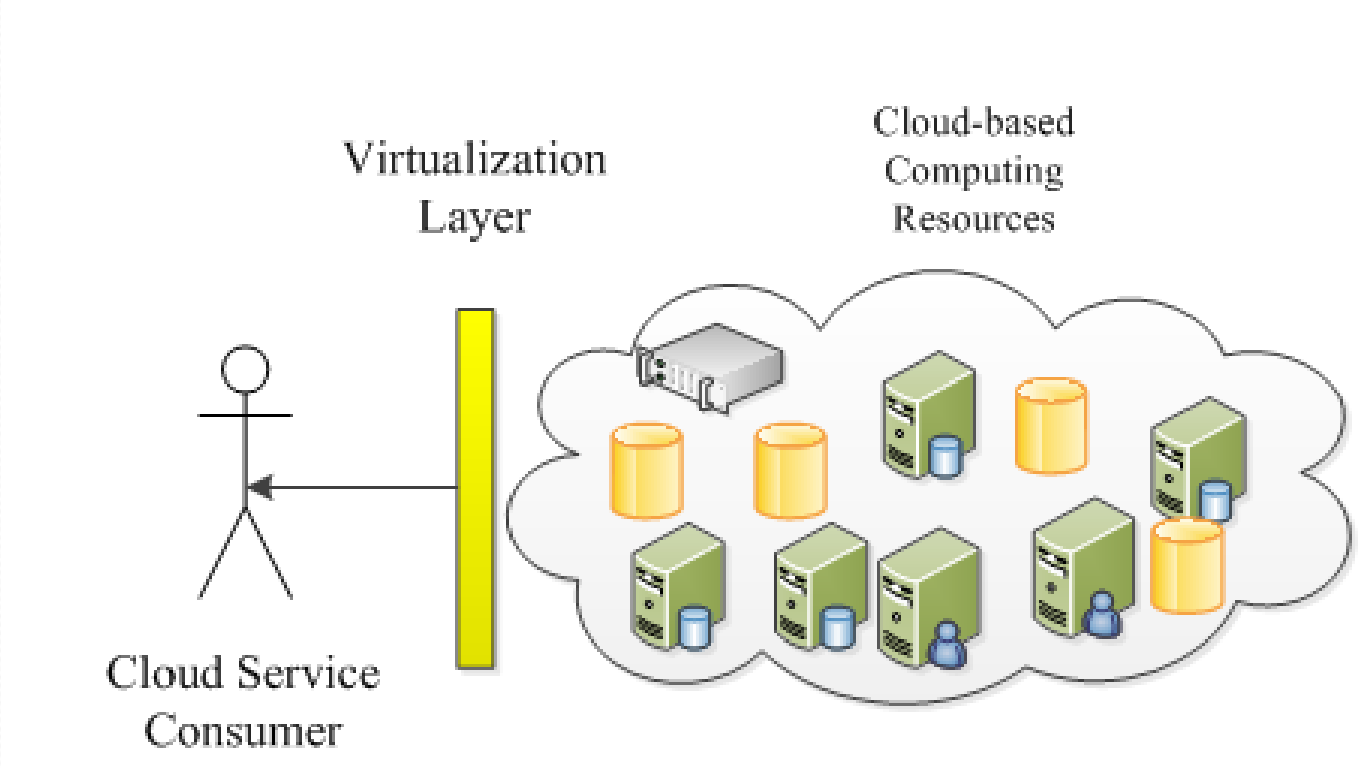


Figure : Illustration of relationship between cloud resources, virtualization and cloud consumer

Metered computing resource usage

- Typically no start-up fees or set-up fees
  - Sign up, use cloud resource, pay for your usage (based on your consumption of resources)
  - Enables SME's to use large-scale IT resources (by removing the resource procurement barrier)
  - Enables Large Enterprises to consume resources cheaply
  - Fine-Grained Metering and Billing of Resource Usage

Figure : An example of Cloud service pricing

Resource Delivery over the internet

- (Computing) resources are provisioned as a "*service*"
- Resources are delivered over the internet
- Typical services include (hardware (infrastructure); computing platforms; and software)
- API's are provided to access and use the provided resources

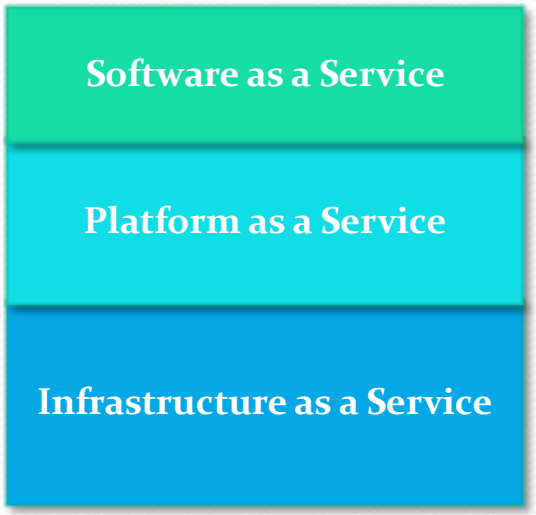


Figure : Different types of Cloud services

Resource Deployment and De-provisioning Automation

- New or additional resources are requested via an API
- The requested resources by the cloud consumer will be configured and made ready to use (a.k.a Resource Provisioning or Deployment)
- The provisioned resources will be de-provisioned when they are not longer required
- No effort or action (apart from informing) from the cloud consumer to provision, configure, maintain, update or de-provision the resources
- Saves time and resources in configuring and deploying of resources

Why Cloud Computing?

- Reduction in business costs
  - CapEx to OpEx (Quantum Shift in capital requirements)
  - Cheaper OpEx costs
  - Reduction of space usage
  - Huge reduction in time and man-power required for planning, purchasing, provisioning, configuring, and disposing resources
- Technology to Core Business Shift
  - Enables organize to focus on core-business activities
  - Gain competitive advantage by focusing on core-business activities

Cloud Computing Obstacles

- Quality of provided service to end users
  - Performance Unpredictability;
  - Internet bottleneck (both at consumer's and provider's side)
- Data Confidentiality and Auditability
  - Distribution of data across the globe
    - Legal Implications of data distribution
  - Risk of Data Leaks
  - No data auditability mechanism

History of Amazon Cloud

- Amazon Cloud
  - Started as an on-line book store, and later expanded its product range in the e-Commerce market
  - Huge growth in online-presence over the years
  - Innovative business strategies (such as Amazon Merchants and Market places) exacerbated business growth
  - Business growth implied large data storage and computing resources from Amazon
  - Peak sales duration around December
  - Led to overprovisioning of computing resources during the rest of the year
  - Amazon Web Service launched in 2002 sold idle computing resources to other organizations who needed them

Utility computing

- The notion that computing resources can be organized and distributed as a utility (similar to water, electricity, gas, and internet)
- Computing as a “fifth utility” for human beings
- Key aspects of utility computing:
  - Computing resources can be requested and provided to any one on demand;
  - Seamless up-scale and down-scaling of resources from the utility providers;
  - Low or no initial set-up costs;
  - Pay-as-you go resource usage
- Cloud computing is one of the mechanisms for achieving utility computing

(Some) Cloud Computing Applications

- Google Products such as
  - Google Mail (GMail)
  - Google Calendar
  - Google Docs
  - Google Apps
- Microsoft Azure
- Dropbox
- ……
- ……
- Amazon Products such as
  - Amazon Elastic Cloud Compute (EC2)
  - Amazon Storage (S3 etc..)

Reading

Books

1. Rhoton, J. (2010), Cloud computing explained, Recursive Press, UK – Chapters 1, 3-6

2. Shroff, G. (2010), Enterprise cloud computing: technology, architecture, application, Cambridge University Press, UK – Chapters 1 and 2

3. Moyer, C.M. (2011), Building Applications in the Cloud: Concepts, Patterns and Projects, Addison-Wesley, Pearson Education – Chapter 1

Reading

Papers, Websites

1. P. Mell and T. Grance. (2009), The NIST Definition of Cloud Computing. http://www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf.

2. M. Armbrust, A., Fox, R., Griffith, A.D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, and M. Zaharia. (2009). Above the clouds: A Berkeley view of Cloud Computing, UC Berkeley EECS.

3. Open Cloud Manifesto (2009), http://www.opencloudmanifesto.org/