

Yang, Chaowei et al. (2011) 'Spatial cloud computing: how can the geospatial sciences use and help shape cloud computing?', International Journal of Digital Earth, 4: 4, 305 – 329

GEOG 482/582 : GIS Data Management

Lesson 14: Cloud Computing

Overview

Learning Objective Questions:

1. Why is cloud computing attractive?
2. What is cloud computing?
3. What is different in cloud computing?
4. What is the spectrum of cloud computing services?
5. When is utility computing preferable to running a private cloud?
6. What are the top 10 obstacles and opportunities (O&O) of cloud computing?
7. What is spatial cloud computing?
8. What are the four intensities emerging in geospatial sciences in need of spatial cloud computing?
9. What five spatiotemporal principles might we consider to guide us in spatial cloud computing?

Lesson Preview

Learning objective questions act as the lesson outline.

Questions beg answers.

Basics of Cloud Computing

1. Why is cloud computing attractive?

Cloud Computing as...

- computing as a utility (readily available resource); examples of utilities include: electric, gas, water, computing
- potential to transform a large part of the IT industry
- make software even more attractive as a service
- shape the way IT hardware is designed and purchased.

Cloud computing

Innovation at right price...

- Encourage those with innovative ideas for new Internet services
- No need for large capital outlays in hardware to deploy their service or the human expense to operate it.
- When making service available, need not be concerned about....

...over-provisioning for a service

When popularity does not meet their predictions,
no worry of wasting costly resources

...under-provisioning for a service

When service becomes wildly popular,
no worry of missing potential customers and revenue.

Key terms

Scaling is very important to service

- Organizations with large batch-oriented tasks can get results as quickly as their programs can scale,
- Using 1000 servers for one hour costs no more than using one server for 1000 hours.
- Elasticity of resources, without paying a premium for large scale, is unprecedented in the history of IT.

Key terms

2. What is Cloud Computing?

...refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services

Datacenter hardware and software is what we will call a Cloud.

Key terms

Services availability

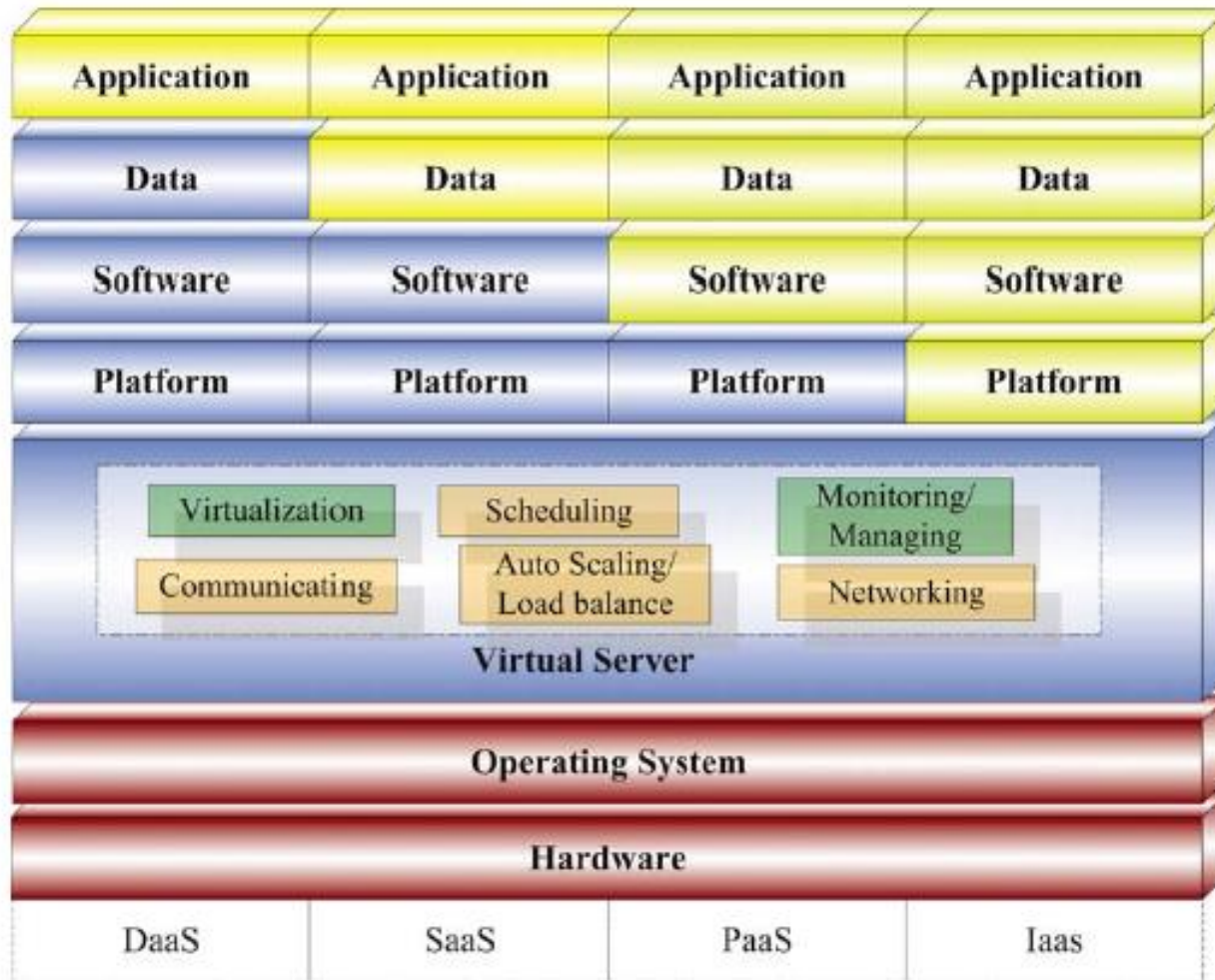
Listed in the order of being most readily available to least at the current time

- Infrastructure as a service (IaaS) – hardware
- Platform as a Service (PaaS) – operating system and hardware
- Software as a Service (SaaS) – software utility, you bring data
- Data as a service (DaaS) – data retrieval using software, OS, hardware
- Application (AaaS) – package DaaS and SaaS on top of PaaS
- Model as a Service (MaaS) – some combination of above

Key terms

Service

Services architecture



Key terms

Yang, Chaowei , Goodchild, Michael , Huang, Qunying , Nebert, Doug , Raskin, Robert, Xu, Yan, Bambacus, Myra and Fay, Daniel (2011) 'Spatial cloud computing: how can the geospatial sciences use and help shape cloud computing?', International Journal of Digital Earth, 4: 4, 305 – 329

Public and Private Clouds

- Public Cloud refers to Cloud made available in a pay-as-you-go manner to the general public; the service being sold is Utility Computing.
- Private Cloud to refer to internal datacenters of a business or other organization, not made available to the general public. Geography servers could be considered a rather small private cloud.
- Thus, Cloud Computing is the sum of SaaS and Utility Computing, but does not include Private Clouds.
- Why bother with a private cloud? Configurability is much more flexible. In public cloud, can only purchase what service is available.

Key terms

Consumers and Providers of Services

- People can be users or providers of SaaS, or users or providers of Utility Computing.
- Berkeley paper focuses on SaaS Providers (Cloud Users) and Cloud Providers,
- Those have received less attention than SaaS Users.

Key terms

3. What is different in Cloud Computing?

From a hardware point of view, three aspects are different in Cloud Computing in contrast to conventional computing.

1. Illusion of infinite computing resources available on demand, thereby eliminate need for Cloud Computing users to plan far ahead for provisioning.
2. Eliminate up-front commitment by Cloud users, thereby allowing companies to start small and increase hardware resources only when there is an increase in their needs.
3. Ability to pay for use of computing resources on a short-term basis as needed (e.g., processors by the hour and storage by the day) and release them as needed, thereby rewarding conservation by letting machines and storage go when they are no longer useful.

Key terms

Key Factors for Considering Services

Interesting that several factors are of concern due to “economic geography” perspective

- Construction and operation of extremely large-scale, commodity-computer datacenters at low-cost locations was the key necessary enabler of Cloud Computing,
- 5 to 7 decrease in cost of electricity, network bandwidth, operations, software, and hardware available at these very large economies of scale.
- Statistical multiplexing to increase utilization compared a private cloud, meant that cloud computing could offer services below the costs of a medium-sized datacenter and yet still make a good profit.

Key terms

4. What is the spectrum of cloud computing services?

Spectrum of service offering:

IaaS – provide hardware only

PaaS – provide hardware and operating system

SaaS – provide hardware, operating system, and other software

DaaS – provide database manager software on top of above

AaaS – refers to package of DaaS and SaaS

MaaS – some specific combination of above

Key terms

Models for service provision (acquisition)

- Models needed for achieving elasticity and illusion of infinite capacity of services
- Models of storage, computation, and communication needed
- Requires resources (computation, storage, and communication) to be virtualized
- Virtualization hides the implementation of how they are multiplexed and shared.

Key terms

Different organizations offering different level of computing across the spectrum

Offering often distinguished based on the level of abstraction presented to the programmer and the level of management of the resources. For example, in recent past (from end to end)...

Key terms

- At one time, Amazon EC2 (now AWS) was at one end of the spectrum: hardware only
- Microsoft Azure was middle of spectrum: hardware and OS
- Google AppEngine was at other end of spectrum: hardware, OS and application
- All three are now offering all levels of services. So, how do we differentiate them?

Amazon Cloud: AWS offering

EC2 (AWS) instance looks much like physical hardware, and users can control nearly the entire software stack, from the kernel upwards.

This offering makes it inherently difficult to achieve automatic scalability and failover, because the semantics associated with replication and other state management issues are highly application-dependent.

Key terms

Microsoft Cloud: Azure offering

- Applications for Microsoft's Azure
 - written using the .NET libraries,
 - compiled to the Common Language Runtime
 - language-independent managed environment.
- Azure is intermediate between application frameworks like AppEngine and hardware virtual machines like EC2.

Key terms

Google Cloud: AppEngine offering

- At the other end of the spectrum are application domain specific platforms such as Google AppEngine.
- AppEngine is targeted exclusively at traditional web applications, enforcing an application structure of clean separation between a stateless computation tier and a stateful storage tier.
- AppEngine's impressive automatic scaling and high-availability mechanisms, and the proprietary MegaStore data storage available to AppEngine applications, all rely on these constraints.

Key terms

5. When is utility computing preferable to running a private cloud?

- Case 1. When demand for a service varies with time.
- Case 2. When demand is unknown in advance

Key terms

Case 1. When demand for a service varies with time.

- Provisioning a data center for the peak load it must sustain a few days per month leads to underutilization at other times, for example.
- Cloud Computing lets an organization pay by the hour for computing resources, potentially leading to cost savings even if the hourly rate to rent a machine from a cloud provider is higher than the rate to own one.

Key terms

Case 2. When demand is unknown in advance

- web startup will need to support a spike in demand when it becomes popular, followed potentially by a reduction once some of the visitors turn away.
- Organizations that perform batch analytics can use the "cost associativity" of cloud computing to finish computations faster
- using 1000 EC2 machines for 1 hour costs the same as using 1 machine for 1000 hours.

Key terms

6. What are top 10 obstacles and opportunities (O&O) of cloud computing?

Obstacles 1-3: concern adoption

Obstacles 4-8: affect growth

Obstacles 9-10: policy and business obstacles

Key terms

Table 1: Quick Preview of Top 10 Obstacles to and Opportunities for Growth of Cloud Computing.

	Obstacle	Opportunity
1	Availability of Service	Use Multiple Cloud Providers; Use Elasticity to Prevent DDOS
2	Data Lock-In	Standardize APIs; Compatible SW to enable Surge Computing
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, Firewalls; Geographical Data Storage
4	Data Transfer Bottlenecks	FedExing Disks; Data Backup/Archival; Higher BW Switches
5	Performance Unpredictability	Improved VM Support; Flash Memory; Gang Schedule VMs
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler that relies on ML; Snapshots for Conservation
9	Reputation Fate Sharing	Offer reputation-guarding services like those for email
10	Software Licensing	Pay-for-use licenses; Bulk use sales

Product development and/or research project opportunities overcome obstacles

Considerations for the future...

1. Cloud Computing has grown substantially and will likely continue to grow
2. All levels should aim at horizontal scalability of virtual machines over the efficiency on a single VM.
3. Applications software needs to both scale down rapidly as well as scale up, which is a new requirement. Such software also needs a pay-for-use licensing model to match needs of Cloud Computing.
4. Infrastructure software needs to be aware that it is no longer running on bare metal but on VMs. Moreover, it needs to have billing built in from the beginning.
5. Hardware systems should be designed at the scale of a container (at least a dozen racks), which will be is the minimum purchase size.

Key terms

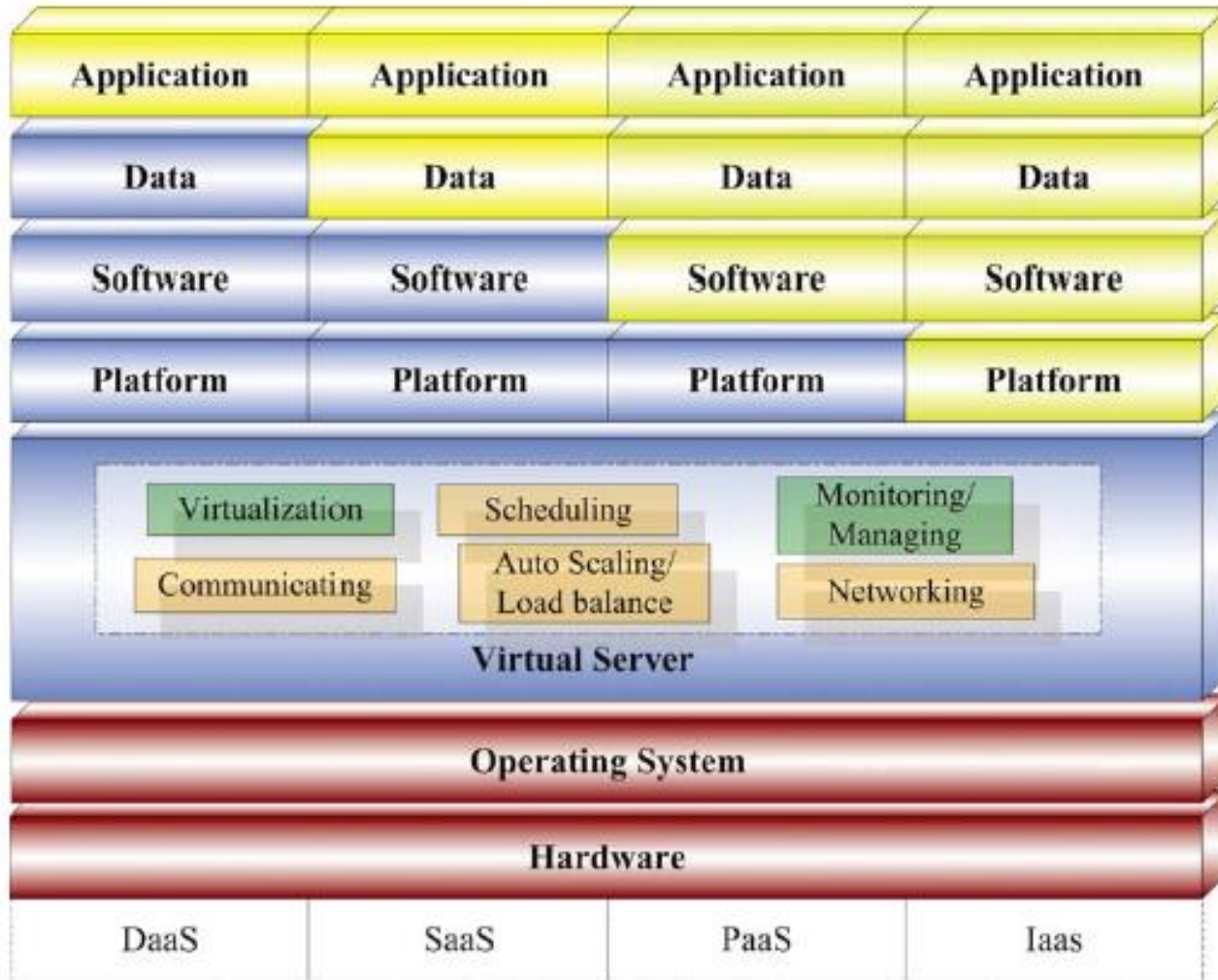
7. What is spatial cloud computing?

Cloud computing that takes advantage of 'spatial relationships' is called... Spatial cloud computing...

cloud computing paradigm that is driven by geospatial sciences, and optimized by spatiotemporal principles for enabling geospatial science discoveries and cloud computing within distributed computing environment.

Cloud computing

Services Architecture as before



Key terms

8. What are the four intensities emerging in geospatial sciences in need of spatial cloud computing?

Geospatial sciences faces grand information technology (IT) challenges in the twenty-first century:

- data intensity - larger volumes of data
- computing intensity – more CPU cycles needed to address more complex problems; or problems in more detail.
- multi-user concurrent access intensity – larger and larger numbers of concurrent users
- spatiotemporal intensity – space-time observations related to other space-time observations creates more relationships of interest

Key terms

An example of GEOSS workflow and intensities

- GEOSS (global earth observation system of systems) is a group of 140+ nations interested in understanding of global earth systems; geospatial workflow (applications) of interest; but many organizations have similar needs



Figure 1. System of systems solution includes Earth observation, parameter extraction, model simulations, decision support, social impact and feedback.

Aligning geospatial intensity challenges with geospatial workflow...

Table 1. The relationship between the elements of geospatial sciences and the issues of data, computing, spatiotemporal, and concurrent intensities.

Intensiveness\elements	Observation	Parameter extraction	Modeling	Information integration/ visualization	Decision-making	Social impact
Data intensive	x	x	x	x		
Computing intensive		x	x	x		
Concurrent access intensive				x	x	x
Spatiotemporal intensive	x	x	x	x	x	x

9. What five spatio-temporal principles might we consider to guide us in spatial cloud computing?

- (1) physical phenomena are continuous and digital representations are discrete for both space and time;
- (2) physical phenomena are heterogeneous in space, time, and space-time scales;
- (3) physical phenomena are semi-independent across localized geographic domains and can, therefore, be divided and conquered;
- (4) geospatial science and application problems include the spatiotemporal locations of the data storage, computing/processing resources, the physical phenomena, and the users; all four locations interact to complicate the spatial distributions of intensities; and
- (5) spatiotemporal phenomena that are closer are more related (Tobler's first law of geography).

Spatial cloud computing platform should leverage those spatiotemporal principles.

Key terms

Spatiotemporal principles

Summary

In this lesson, you learned about...

1. Why cloud computing is attractive
2. What cloud computing is
3. The difference in cloud computing
4. The spectrum of cloud computing services
5. Utility computing preferability to running a private cloud
6. Top 10 obstacles and opportunities (O&O) of cloud computing
7. Spatial cloud computing
8. Four intensities emerging in geospatial sciences
9. Five spatiotemporal principles for cloud computing

NEXT

replace

Contact me at
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have questions or
comments about this
lesson.

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END Lesson 14: Cloud Computing