

Introduction to Engineering Using Robotics Experiments

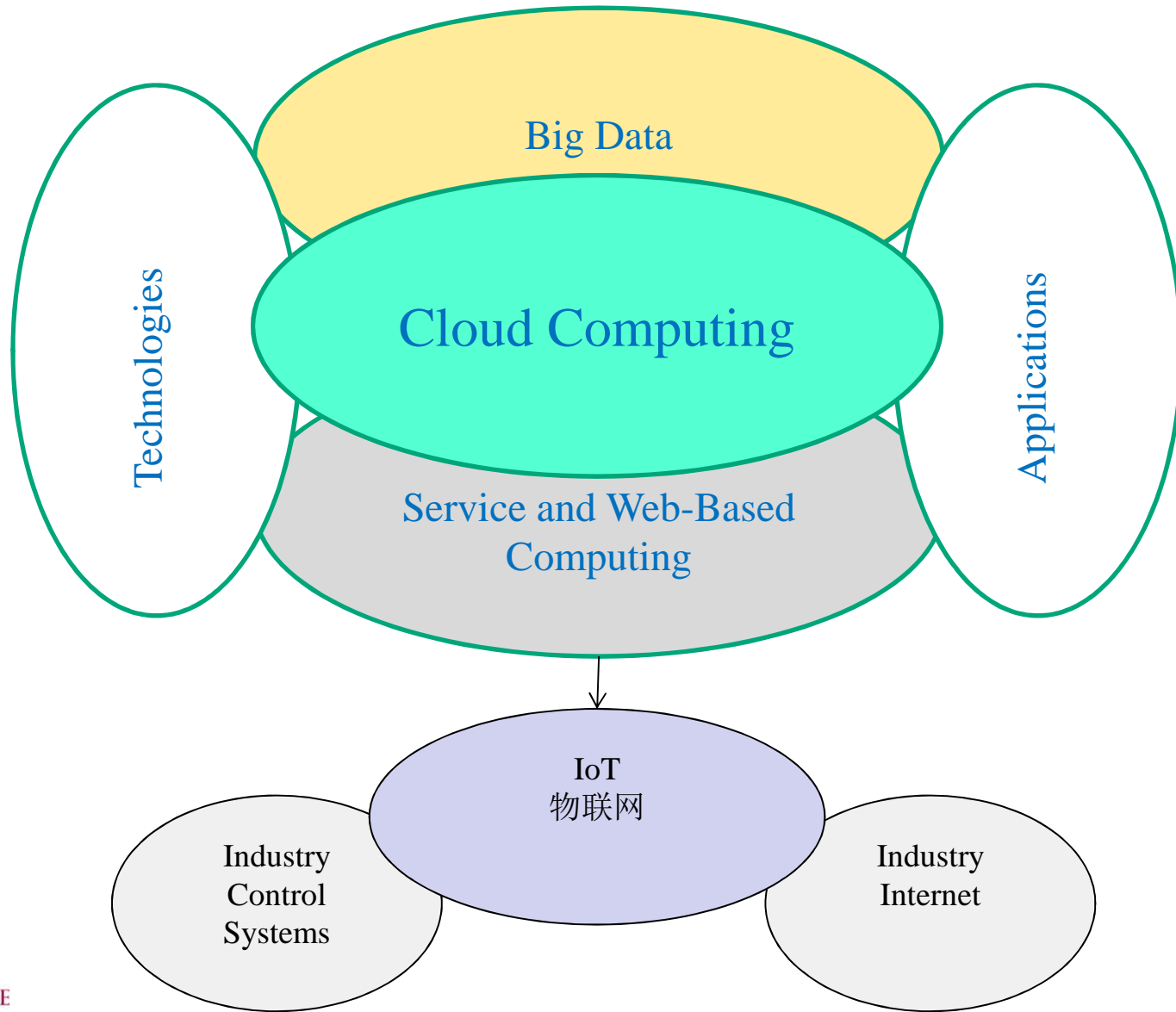


Lecture 18

Cloud Computing

Yinong Chen

Big Data





Lecture Outline

3

- **Cloud Computing as Big Data Infrastructure**
 - Cloud Computing
 - Scalability for supporting big data
 - Parallel computing systems

Vivek Kundra's "Cloud First" Policy

<https://www.dhs.gov/sites/default/files/publications/digital-strategy/federal-cloud-computing-strategy.pdf>

- U.S. Government's "Cloud First Policy"
- Government agencies have been asked to consider a cloud computing option first when they planned to launch a new IT project; and they are required to identify three systems they would like to move to the cloud.
- Kundra believes Cloud Computing is the next "Internet" that has changed the world, not just computing!



联邦云计算策略

<http://washingtontechnology.com/articles/2011/02/18/kundra-plan-25-percent-of-it-spending-on-cloud.aspx>

Cloud computing headed for \$20B market

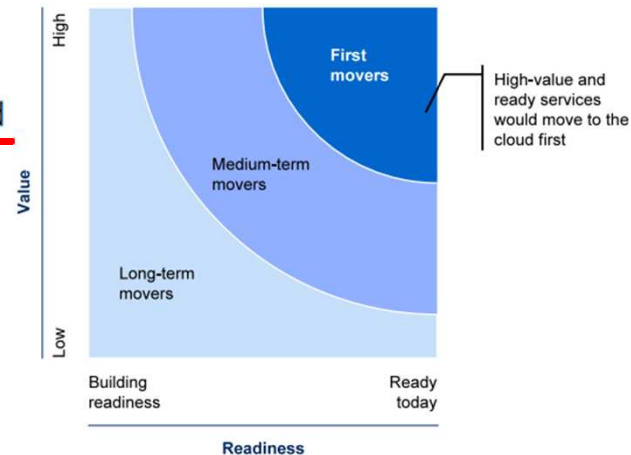
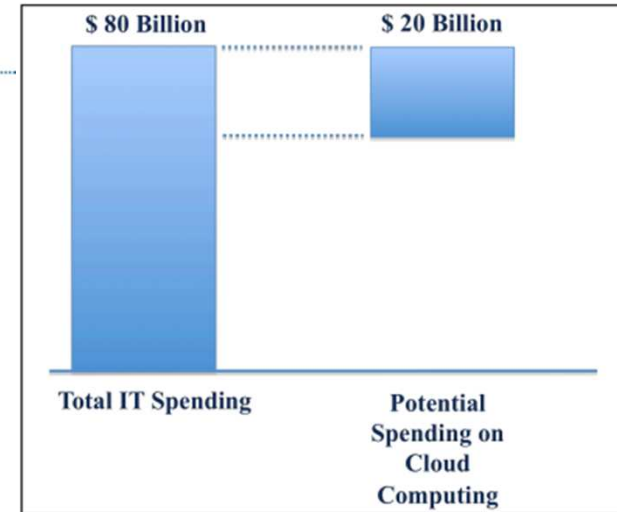
Administration strategy calls for data center reduction to pay for plan

By Kathleen Hickey Feb 18, 2011

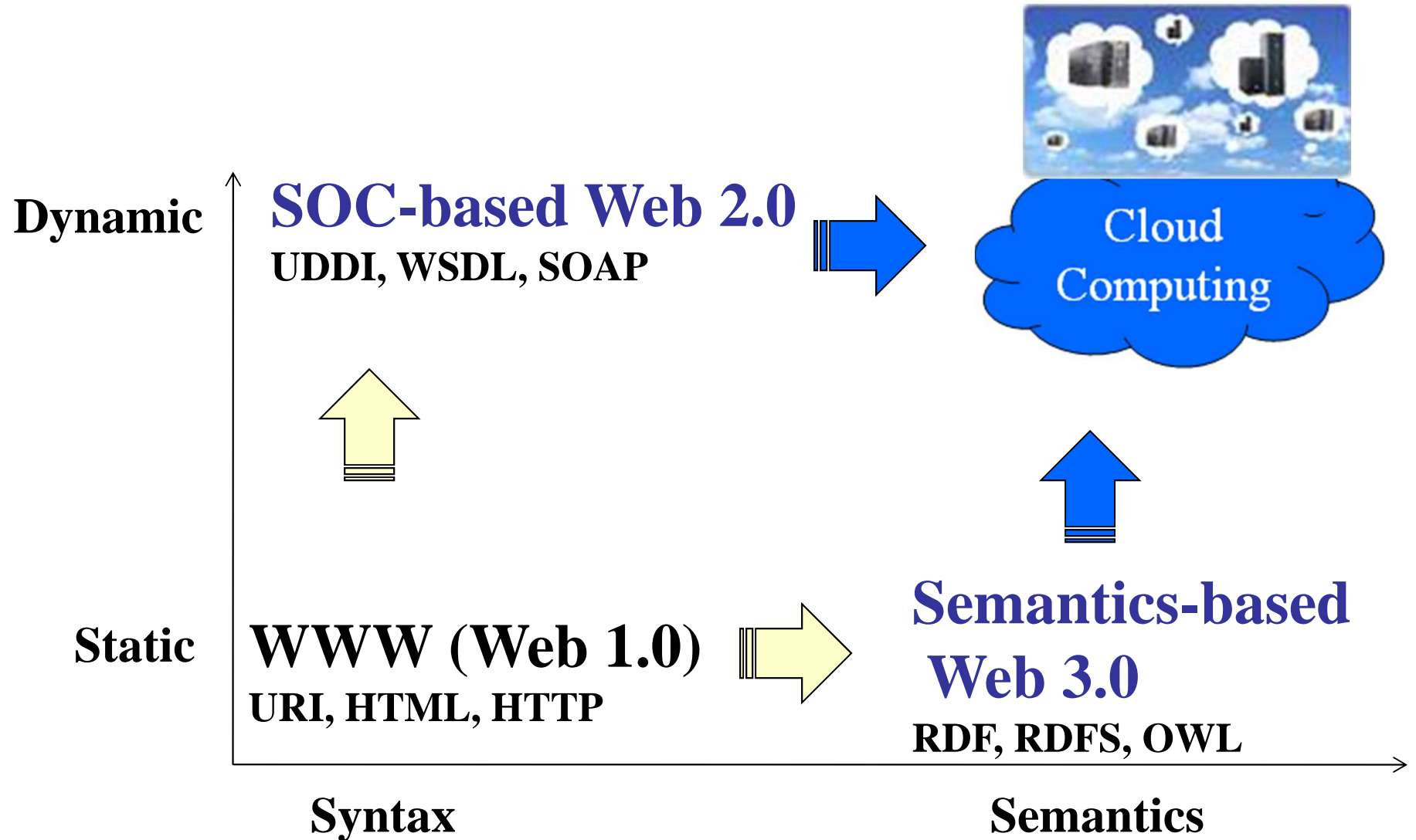
The market for cloud services is about to explode in the government space if Federal CIO Vivek Kundra has his way. His recently released [Federal Cloud Computing Strategy](#) calls for about a quarter of federal IT spending, or \$20 billion, to be committed to cloud systems.

Additionally, under the Cloud First program, agencies will be required to move three services to the cloud within 18 months, adopt a cloud model wherever feasible and evaluate cloud options before making investments.

An estimated \$20 billion of the federal government's \$80 billion in IT spending could be used for cloud computing, Kundra said in the report. The agencies expected to spend the most on cloud technology are the Homeland Security and Treasury departments, at approximately \$2.4 billion apiece, followed by the Defense, Veterans Affairs and Transportation departments. The top contractors at those agencies include companies such as Hewlett-Packard, Computer Sciences Corp., IBM, and Lockheed Martin.



Web 2.0, Web 3.0, and Cloud Computing



Cloud Computing and IoT as a Service

- ❖ **Software as a Service**
- ❖ **Platform as a Service**
- ❖ **Infrastructure as a Service**
- ❖ **X as a Service**
 - **IoT as a Service**
 - ✓ **Cyber Physical Device**
 - ✓ **Device as a Service**
 - ✓ **Robot as a Service (RaaS)**
 - ✓ **Mobile phone**

8 Cloud Computing Standards

- The U. S. National Institute of Standards and Technology (NIST) has been designated by the U.S. Federal Chief Information Officer (CIO) to accelerate the federal government's secure adoption of cloud computing by leading efforts to identify existing standards and guidelines.
- The NIST Cloud Computing Program was formally launched in November 2010.
- The NIST Cloud Computing Program has developed a Cloud Computing Technology Roadmap for the U.S. Government (USG) secure and effective adoption of the Cloud Computing model to reduce costs and improve services.
- NIST Cloud Computing Roadmap Doc: June 18, 2013:
http://www.nist.gov/itl/cloud/upload/NIST_SP-500-291_Version-2_2013_June18_FINAL.pdf

NIST Definition of Cloud Computing

9

- **Cloud Computing** is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
- Essential Characteristics:
 - On-demand self-service: A consumer can choose computing capabilities, without human interaction with service provider.
 - Broad network access: Capabilities are available cross networks.
 - Resource pooling: The computing resources are pooled to serve multiple consumers using a multi-tenant model.
 - Rapid elasticity. Capabilities can be elastically provisioned and released automatically.

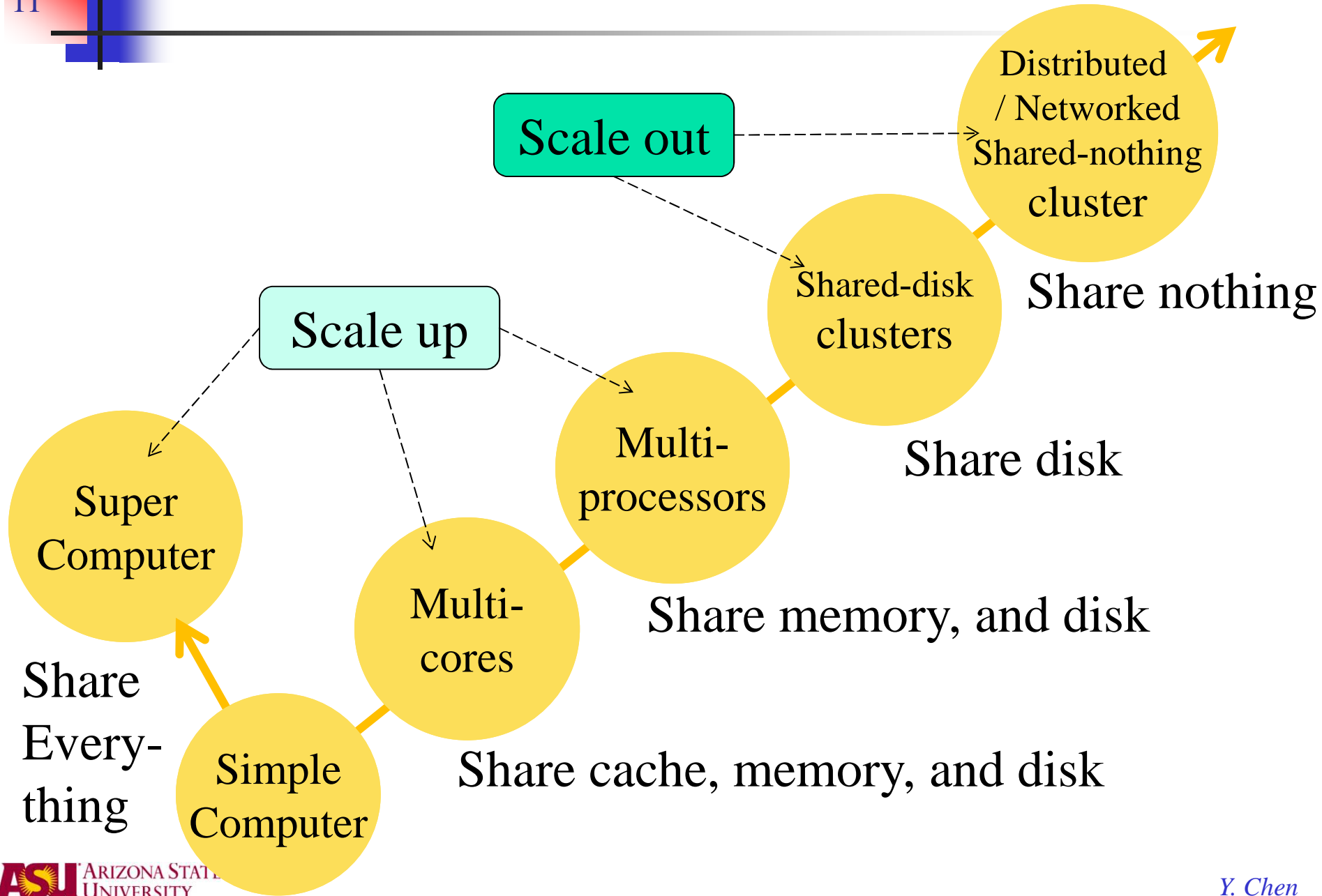
Measured service. Cloud can be measured and optimized.

Infrastructure Supporting Big Data

- Scale up from database to Big Data:
 - Database to distributed data warehouses / centers
- Scale up and scale out computing facilities
 - Scale up from computer to super computer:
Scalability is limited.
 - Scale out from single computer to multiple computers and cluster of computers
 - Virtualize many computers into cloud computing

Scale Up and Scale Out Computing Facilities

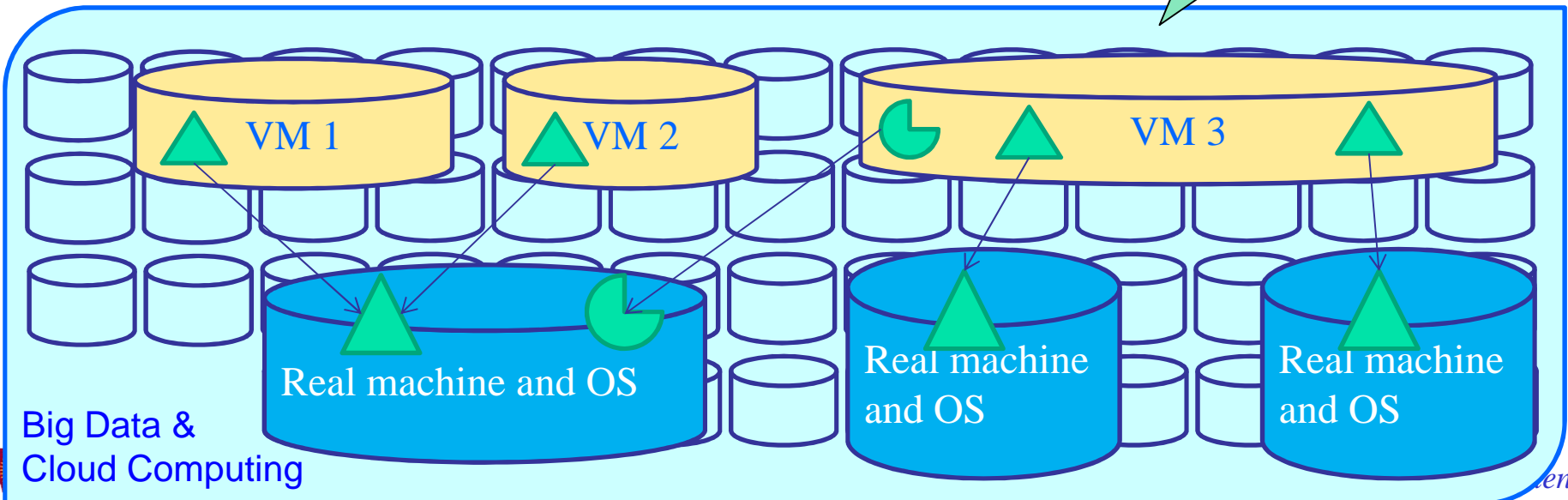
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Virtualization and Cloud Computing

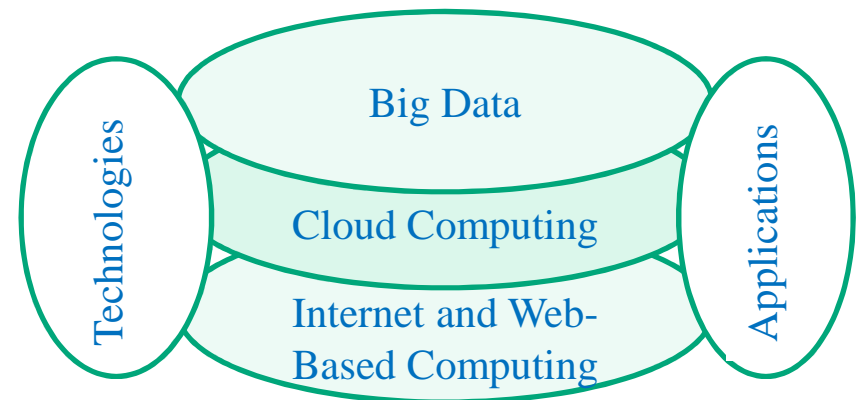
- Maps virtual resources to physical resources
 - Memory, I/O devices, CPUs
- Guest OS runs on native machine in user mode
 - Traps (system library functions) to VMM on privileged instructions and access to protected resources
 - Resource lock when being accessed.
- Guest OS may be different from host OS
- Real OS managers handle real I/O devices
 - Emulates generic virtual I/O devices for guest

How can we manage the processors and the tasks on them?



Web-Based Computing and Cloud Computing

- Web-based computing is rapidly expanding
 - For every desktop application, an web version exists or is being developed;
 - Web 2.0, SOAP services and RESTful services
 - Web 3.0, RDF, OWL ontology and semantic Web
- Cloud computing model: Moving from desktop computing to Web-based computing and enabling programs and data access anywhere and anytime through:
 - SaaS (Software as a Service)
 - PaaS (Platform as a Service)
 - IaaS (Infrastructure as a Service)
 - Data as a Service (DaaS)



More Cloud Units

- Data as a Service: Data center and data services
- Hardware as a Service (**HaaS**):
 - Any piece of hardware can be designed as a service
 - A software service can be implemented in hardware
 - Moving hardware software interface from instruction set to service interface, such as WSDL
- Robot as a Service (**RaaS**): Service repository, service directory, and service client are implemented on a robot
- Test as a Service (**TaaS**)
- X as a Service (**XaaS**) and Internet of Things (IoT):
Anything can be implemented as a service

Where Does Cloud Computing Come From?

- Service-Oriented Computing and Web-Based Computing
- Visualization
- Database, Data Center, and Data warehouse
- Super Computing Systems (Scale Up)
- Parallel and Distributed Computing (Scale Out)
- Do we have cloud computing first or big data first?



Cloud
Computing



Big
Data

Cloud Computing Providers

- ❑ Google App Engine: Free account with limited resources; Java and Python based; Supported by Google APIs and services;
- ❑ Microsoft Windows Azure: C# and .Net based; Supported by Microsoft CRM (Customer Relationship Management), ERP (Enterprise Resource Planning), and Web services;
- ❑ Salesforce.com: Large # of services in CRM & ERP;
- ❑ Amazon Elastic Compute Cloud: Large number of services in e-commerce, supported by development platform and infrastructure.