Cloud Computing

Platform as a Service

Agenda

- Introduction
    - From IaaS to PaaS
    - What is PaaS
    - PaaS properties and characteristics

- Cloud Platform
    - Case studies

From IaaS to PaaS

What is PaaS

PaaS properties and characteristics

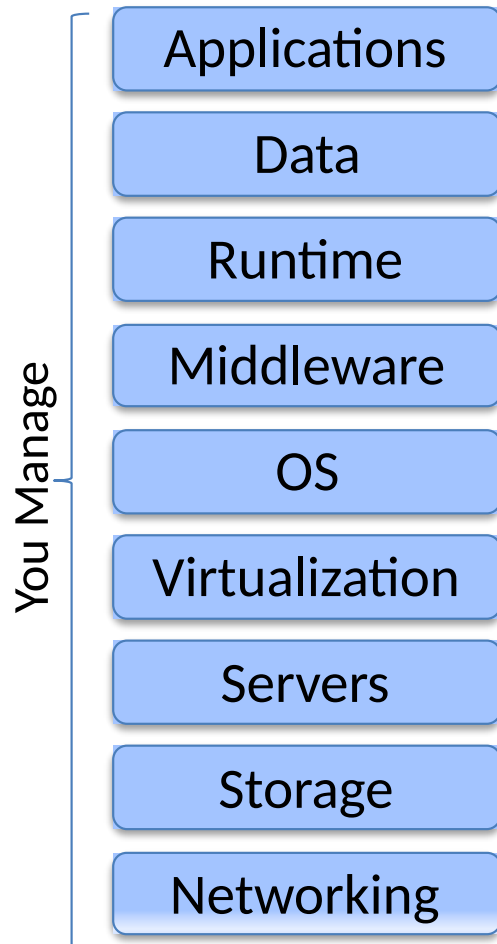# *INTRODUCTION*

What Has IaaS Done

- IaaS provides virtual machines and resources such that IaaS vendors can segment resources for each user
- IaaS providers can also make users do not need to purchase the hardware
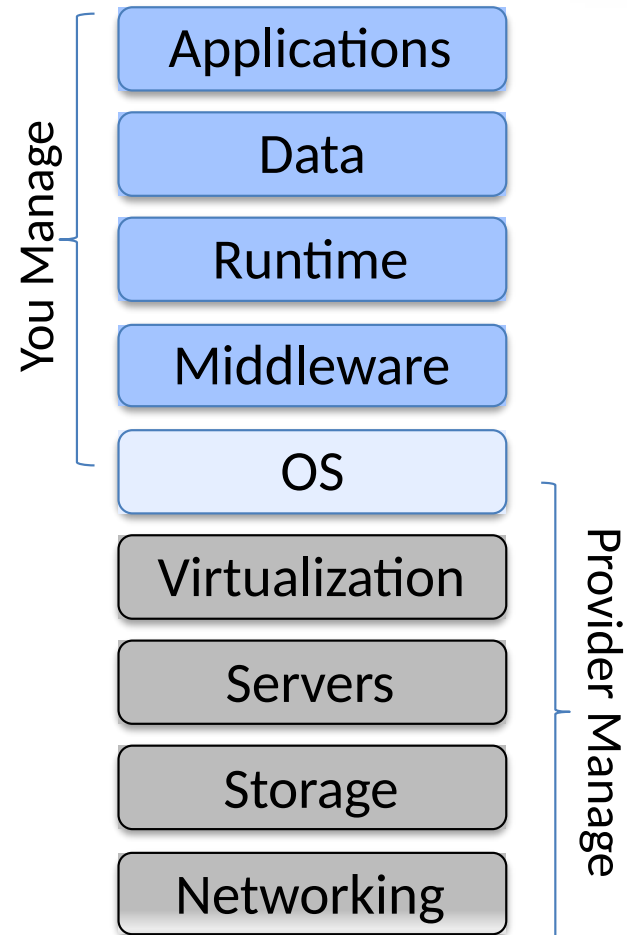- IaaS can make better use of resources

But is it enough?

What IaaS Can Do

- Traditional IT

- IaaS

Traditional IT (You Manage):
- Applications
- Data
- Runtime
- Middleware
- OS
- Virtualization
- Servers
- Storage
- Networking

IaaS:

You Manage:
- Applications
- Data
- Runtime
- Middleware

Provider Manage:
- OS
- Virtualization
- Servers
- Storage
- Networking

IaaS is Not Enough

- IaaS provides many virtual or physical machines, but it cannot alter the quantity automatically

- Consumers might

    - Require automatic make-decisions of dispatching jobs to available resources

    - Need a running environment or a development and testing platform to design their applications or services
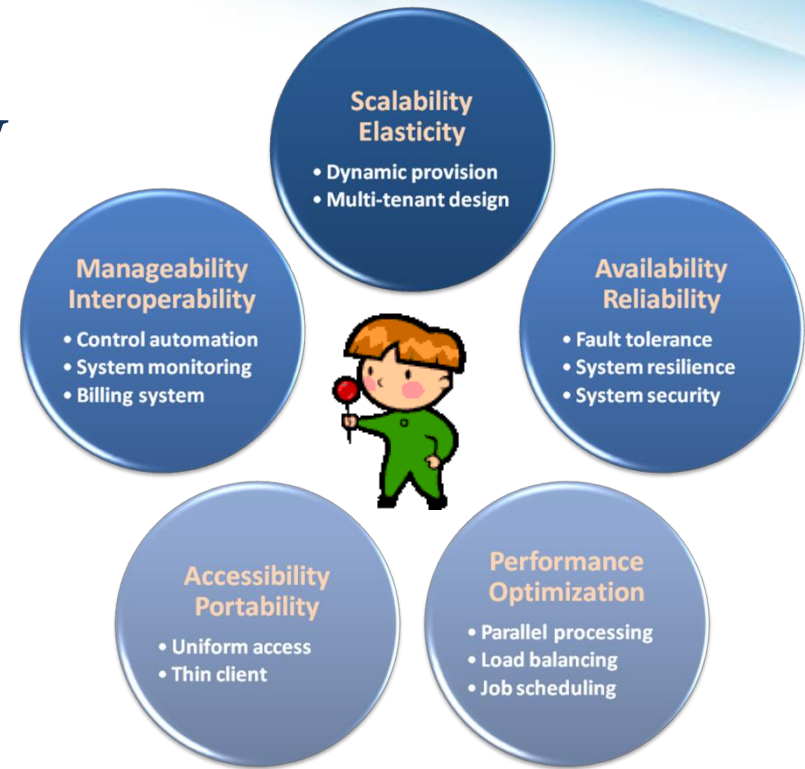
More Requirements

- Consumers require more and more…
  - Large-scale resource abstraction and management
  - Requirement of large-scale resources on demand
  - Running and hosting environment
  - Automatic and autonomous mechanism
  - Distribution and management of jobs
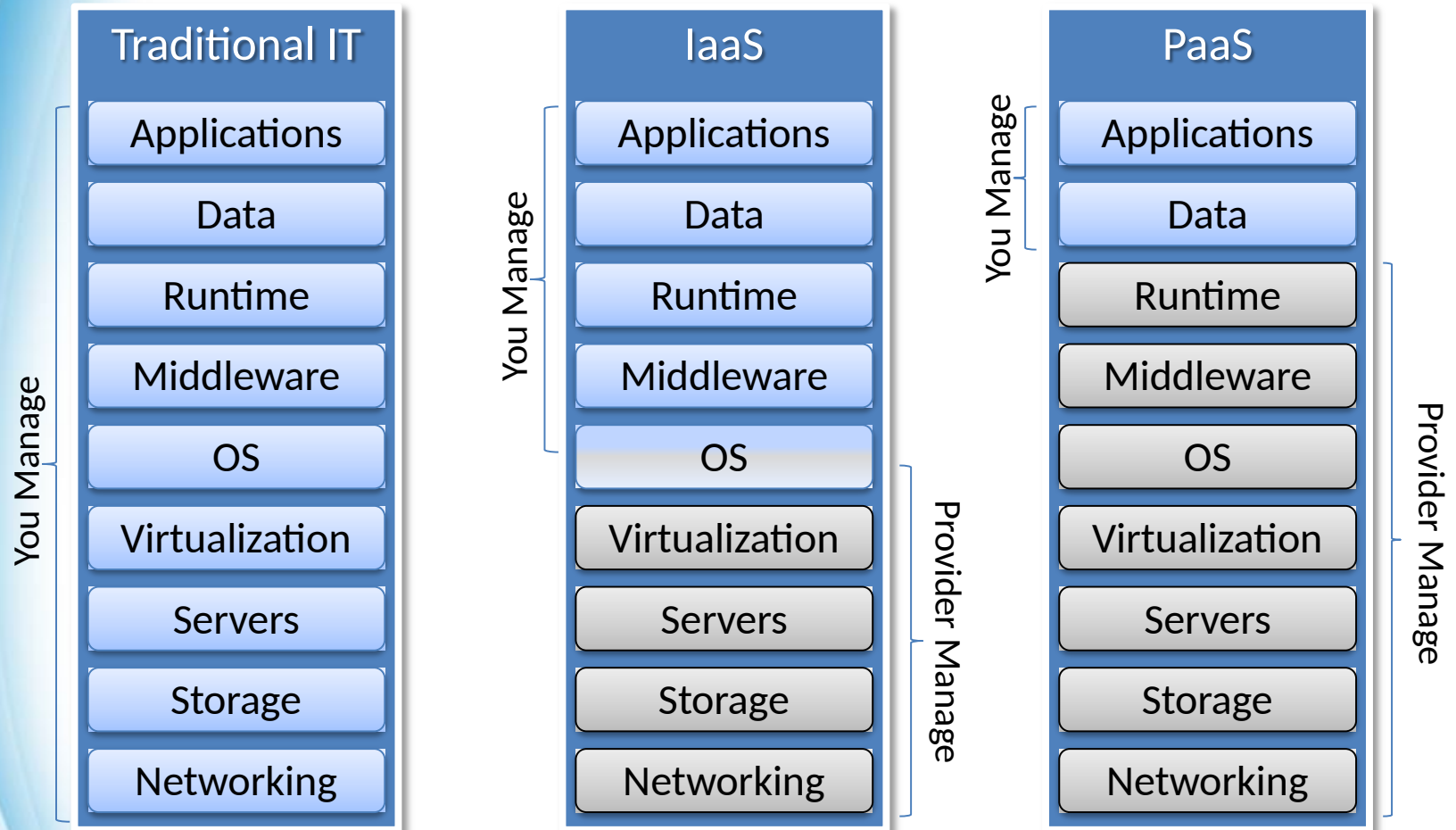 - Access control and authentication
  - …

PaaS Buys It for You

- PaaS provides a series of properties that can satisfy user's requirements

- PaaS guarantees the quality of resources, services and applications

From IaaS to PaaS

Traditional IT

You Manage
- Applications
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- Runtime
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- Storage
- Networking

IaaS

You Manage
- Applications
- Data
- Runtime
- Middleware
- OS

Provider Manage
- Virtualization
- Servers
- Storage
- Networking

PaaS

You Manage
- Applications
- Data

Provider Manage
- Runtime
- Middleware
- OS
- Virtualization
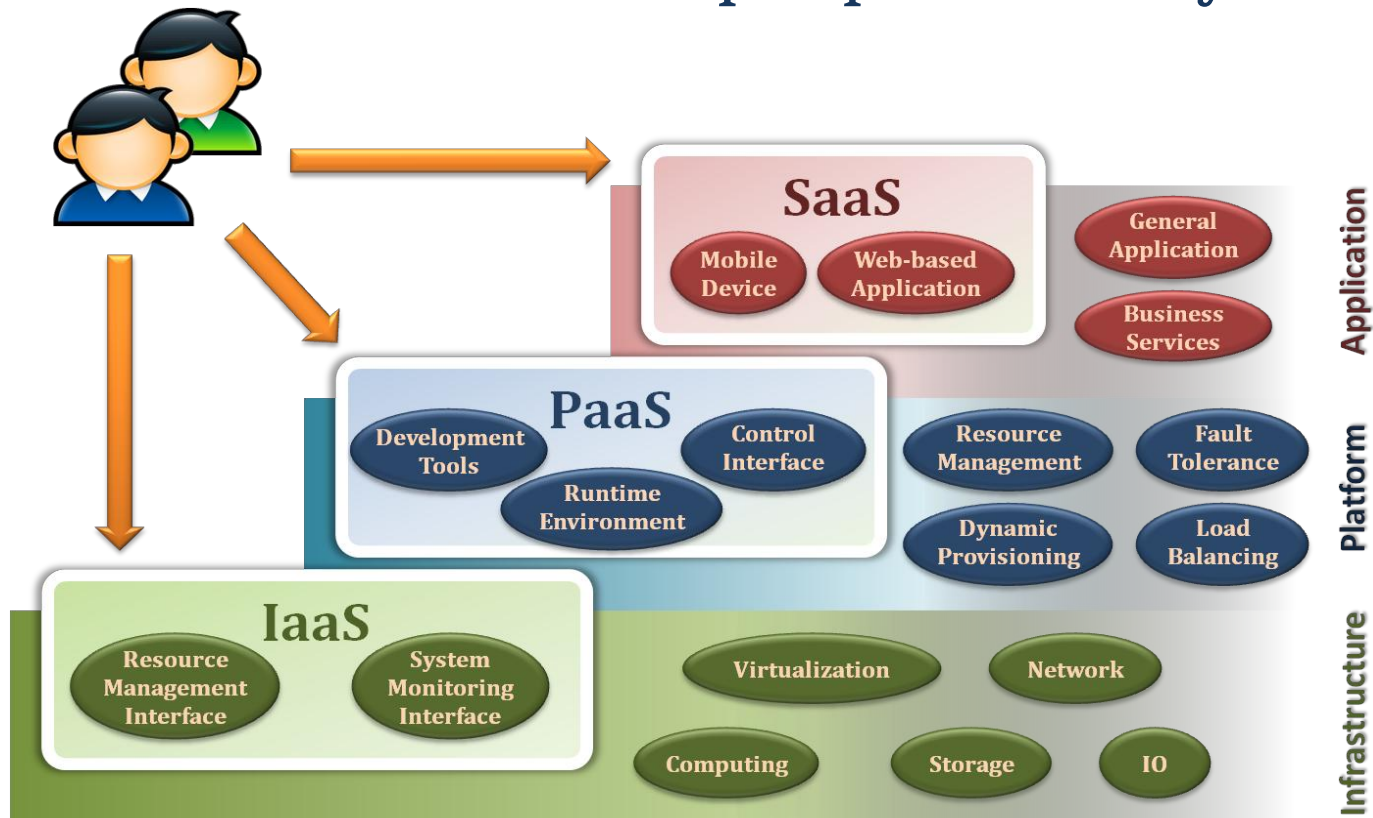- Servers
- Storage
- Networking

From IaaS to PaaS

What is PaaS

PaaS properties and characteristics

INTRODUCTION

Platform as a Service

Platform as a Service (PaaS) is a computing platform that abstracts the infrastructure, OS, and middleware to drive developer productivity

# *Platform as a Service*

- Deliver the computing platform as a service
  - Developing applications using programming languages and tools supported by the PaaS provider
  - Deploying consumer-created applications onto the cloud infrastructure
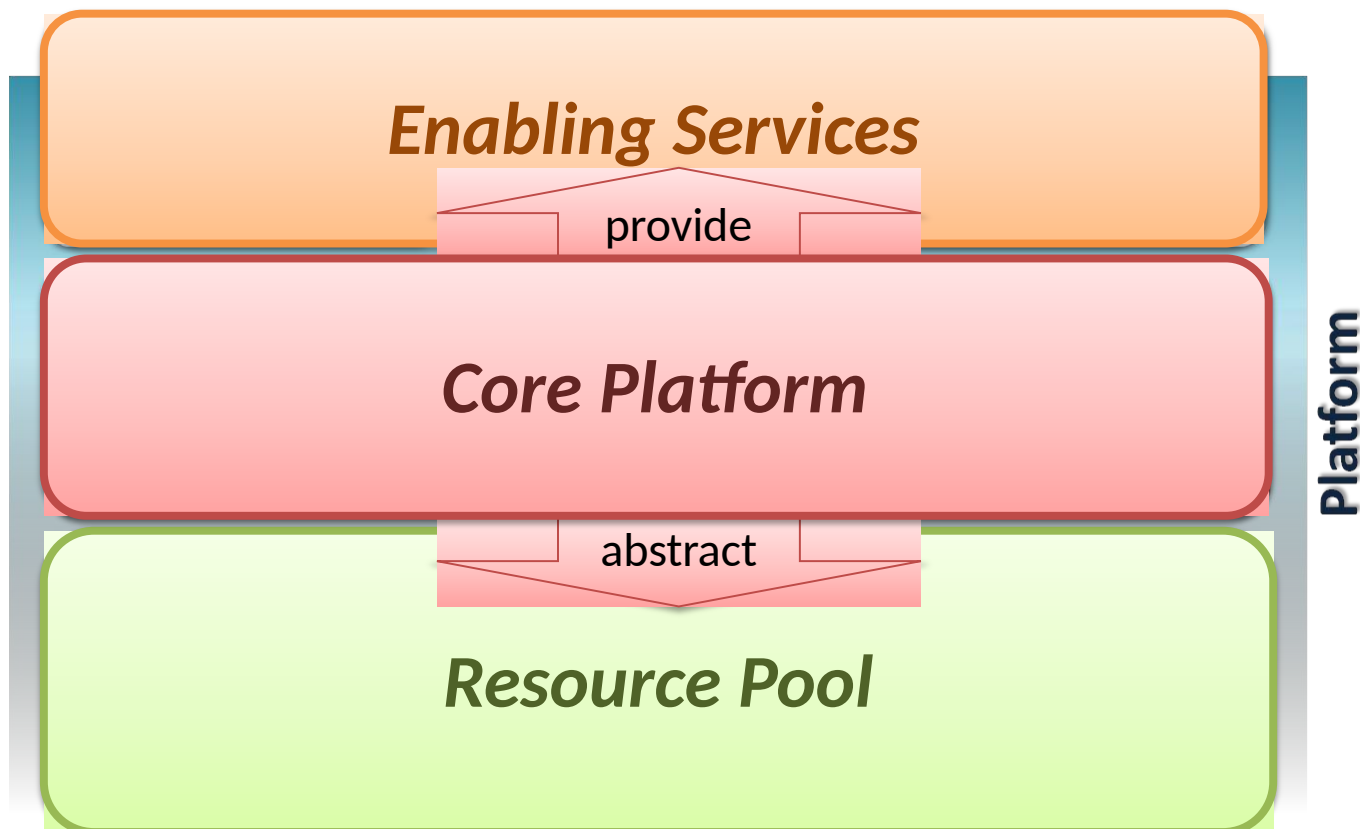
Resource Pool

The capacities to abstract and control all the underlying resources

- Resource Pool dynamically provides an abstraction and consolidation of large-scale resources

- Consumers can acquire and return resources from the resource pool on demand

Enabling Services

provide

Core Platform

abstract
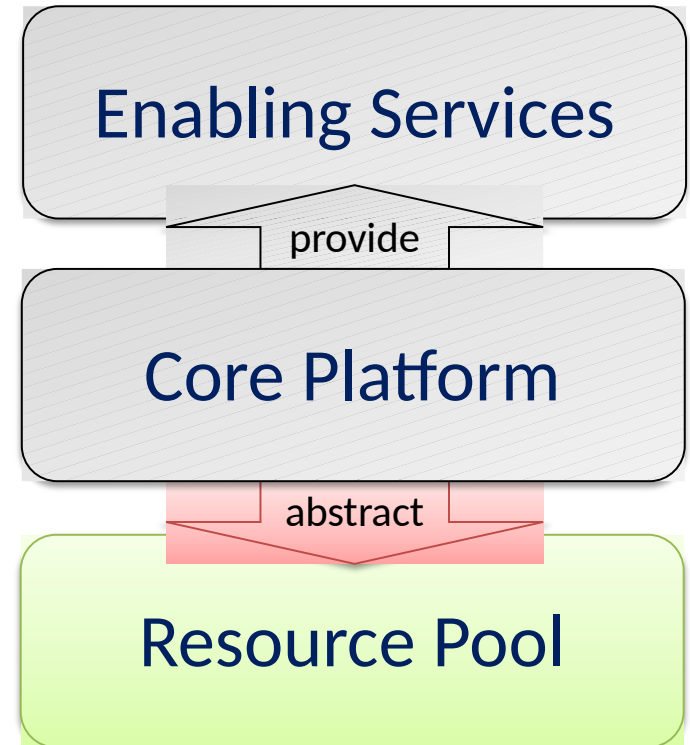
Resource Pool

Resource Pool

- Reduce the complexity and responsibility of cloud infrastructure

- Provide the automatic management to provision resources

- Access resources from the resource pool on demand

Resource Pool

- PaaS providers define the smallest unit of resource
  - 1GHz CPU computation ability
  - 1GB storage space
  - 1MB memory capacity
  - ...etc

- PaaS consumers can require units on their demand
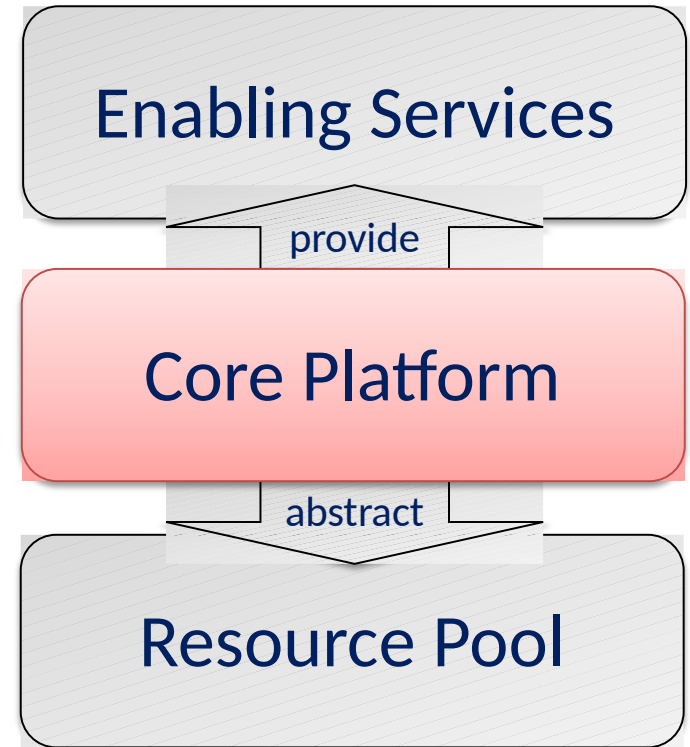- Consumers may not be aware of whether provided resource is dedicate or shared

Core Platform

To provide a reliable environment for running applications and services

- Core Platform provides basic functionalities of a PaaS environment

- Act as a bridge between consumer and hardware

Enabling Services

provide

Core Platform

abstract

Resource Pool

Core Platform

- Reduce the responsibility of the runtime environment

- Based on the core platform to develop their applications

- Do not need to care about how to built, configure, manage and maintain the backend environment
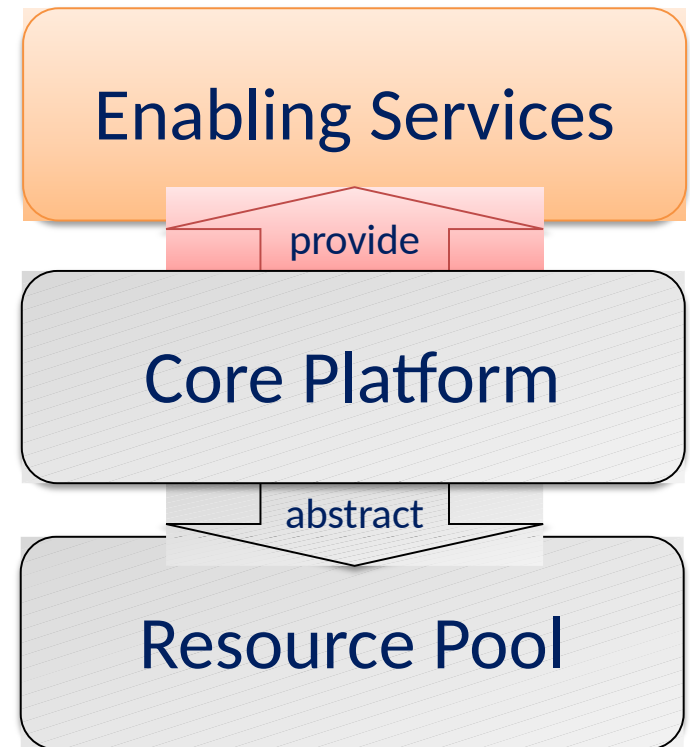
- PaaS providers can provide a runtime environment for the developer platform
- Runtime environment is automatic control such that consumers can focus on their services
    - Dynamic provisioning
        - On-demand resource provisioning
    - Load balancing
        - Distribute workload evenly among resources
    - Fault tolerance
        - Continuously operating in the presence of failures
    - System monitoring
        - Monitor the system status and measure the usage of resources

Enabling Services

To provide platform interfaces and services to drive the development productivities

- Enabling Services provide programming IDE and system control interfaces to access the PaaS environment

- Consumers can develop their applications through the APIs and development tools

Enabling Services

provide

Core Platform

abstract

Resource Pool

Enabling Services

- Provide a development and testing platform for running developed applications on the runtime environment

- Reduce the responsibility of managing the development environment

- Decrease the development period

painful

Enabling Services

- Enabling Services are the main focus of consumers
- Consumers can make use of these sustaining services to develop their applications
  - Programming IDE
    - Integrate the full functionalities supported from the runtime environment
    - Provide some development tools, such as profiler, debugger and testing environment
  - System Control Interfaces
    - Make the decision according to some principles and requirements
    - Describe the flow of installation and configuration of resources

From IaaS to PaaS

What is PaaS

PaaS properties and characteristics

INTRODUCTION

Platform as a Service

- Guarantee some properties and characteristics
    - Scalability
    - Availability
    - Manageability
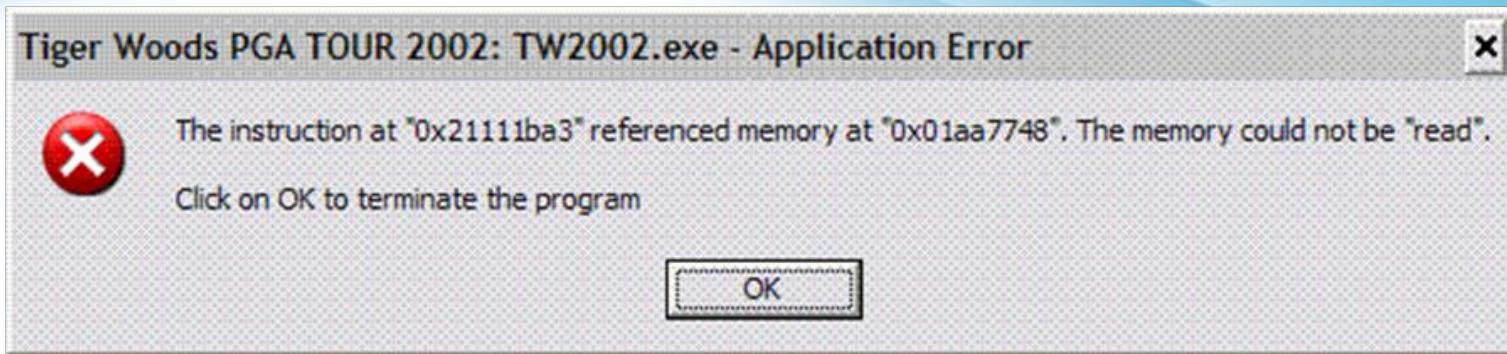   - Performance
    - Accessibility

Scalability

- PaaS needs to support dynamic provisioning that can increase or decrease resources on demand

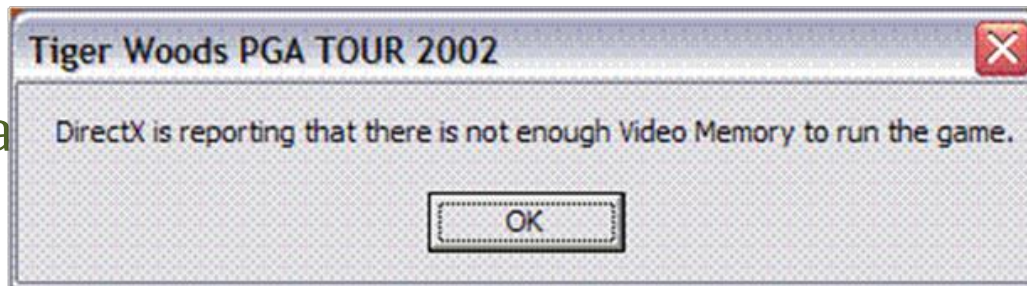- PaaS provides the abstraction of cloud infrastructure and the automatic management

Tiger Woods PGA TOUR 2002: TW2002.exe - Application Error

The instruction at "0x21111ba3" referenced memory at "0x01aa7748". The memory could not be "read".

Click on OK to terminate the program

OK

...ged
...d

- Application may need a high peak of computation usage
  on ...

- It a... ...ne time

Tiger Woods PGA TOUR 2002

DirectX is reporting that there is not enough Video Memory to run the game.

OK

- For end users, they could...
  the lack of memory or sto...
  - For example…

Error Copying File or Folder

Cannot copy PatBentley - Clip 004: There is not enough free disk space.

Delete one or more files to free disk space, and then try again.

To free space on this drive by deleting old or unnecessary files, click Disk Cleanup.

Disk Cleanup...   OK

Availability

- PaaS needs to support the fault tolerance ability such that system would not crash on failure

- PaaS also needs to provide system resilience by duplicating applications or services
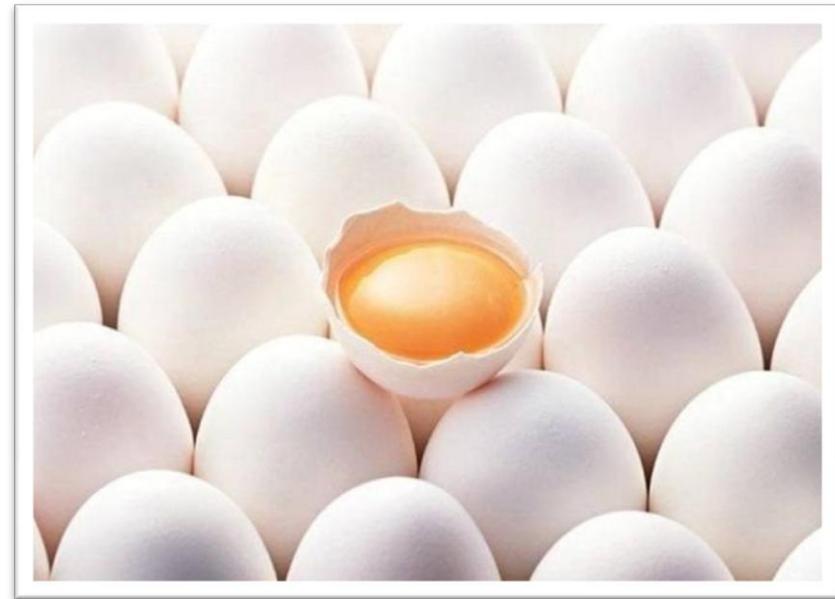
- PaaS supports automatic backup and disaster recovery such that consumers do not need to worry about system failures

- When some resources are failed, PaaS would start up the backup resources

- When applications occur fault, PaaS would migrate services to the duplicate one

There is no error

Manageability

- PaaS needs to support self-management for running applications and services on the cloud platform

- PaaS needs to provide automatic control, analysis and measurement for the resource usage

Manageability

- PaaS provides automatic mechanisms to control the utilization of platform resources

- Monitoring service provides the ability of management, analysis and operation for resources and jobs

- Based on the system monitoring, PaaS can record and report the usage of resources

- Consumers can pay for what they use

- Consumers pay the bill according to how many units of resources and services they use
  - Input/output network bandwidth
  - Management report or warning
  - CPU time
  - Storage space
  - Data migration
  - ...etc

Billing

- Consumers can set the boundary they would not like to pay the overestimate

- PaaS vendor may provide the free quota for users

- PaaS vendor can also alert consumer the suddenly increased usage

- As a result, consumers only pay what they use on demand

Performance

- Enterprise runs complicated applications on PaaS which can allocate jobs to available servers

- If possible, PaaS would run application in parallel

- No resource is always overloading on the load balancing PaaS

- Utilization and performance could be further improved

- Security is an important characteristic in PaaS

- PaaS needs to provide authentication and authorization to differentiate the access rights of different users

Security

- Authorization can be used to control the user's access right and reject the malicious request
- Authentication is the act of establishing or confirming something or someone as authentic
- All of these can limit the malicious behavior

Accessibility

- PaaS needs to provide an interactive interface for consumers to access cloud services or monitor the system status

- Consumers could develop and test their applications via web browsers or other thin-clients

Summary

- PaaS is a magic box
  - Request anything on demand, and return the rent of resources dynamically
  - Automatically build an initial environment and support self-management with high quality of service and performance
  - Provide an ability of fault tolerance and disaster recovery that make services be more available and reliable
  - Support the security property to limit malicious behavior in cloud environments
- More important
  - Do not care about how it works
  - Pay as you go

Case Studies

CLOUD PLATFORM

- PaaS venders
  - Microsoft Windows Azure
  - Hadoop
  - Google App Engine

Microsoft Windows Azure

- Windows Azure platform is one of PaaS vendors
   - Based on .NET and Microsoft's supported development tools
- Windows Azure starts general availability at Feb 2010, and builds the global data center around the world

North American Data Centers   European Data Centers   Asian Data Centers

Dublin

Chicago

Amsterdam

San Antonio

Hong Kong

Singapore

Windows Azure Platform

- A group of cloud technologies, each providing a specific set of services to application developers
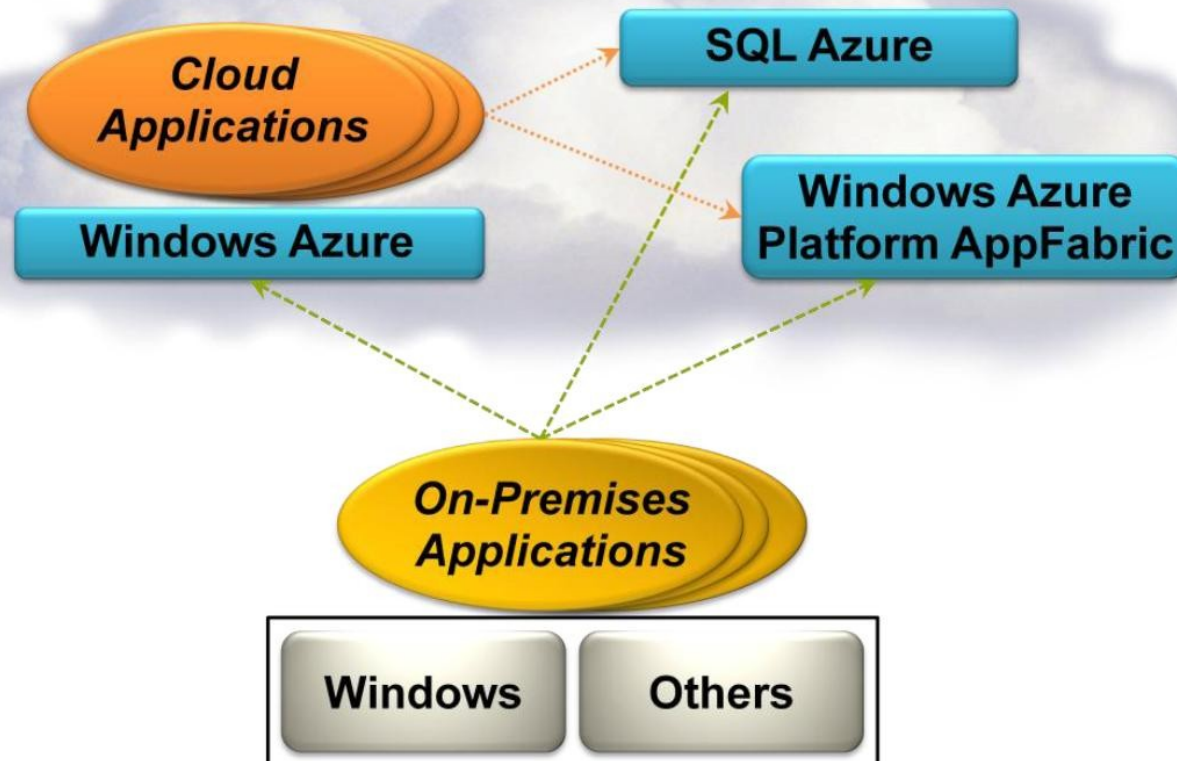
Major Components

- ## Windows Azure
   - Provides a Windows-based environment for running applications and storing data on servers in Microsoft data centers

- ## SQL Azure
   - Provides data services in the cloud based on SQL Server

- ## AppFabric
   - Provides cloud services for connecting applications running in the cloud or on premises
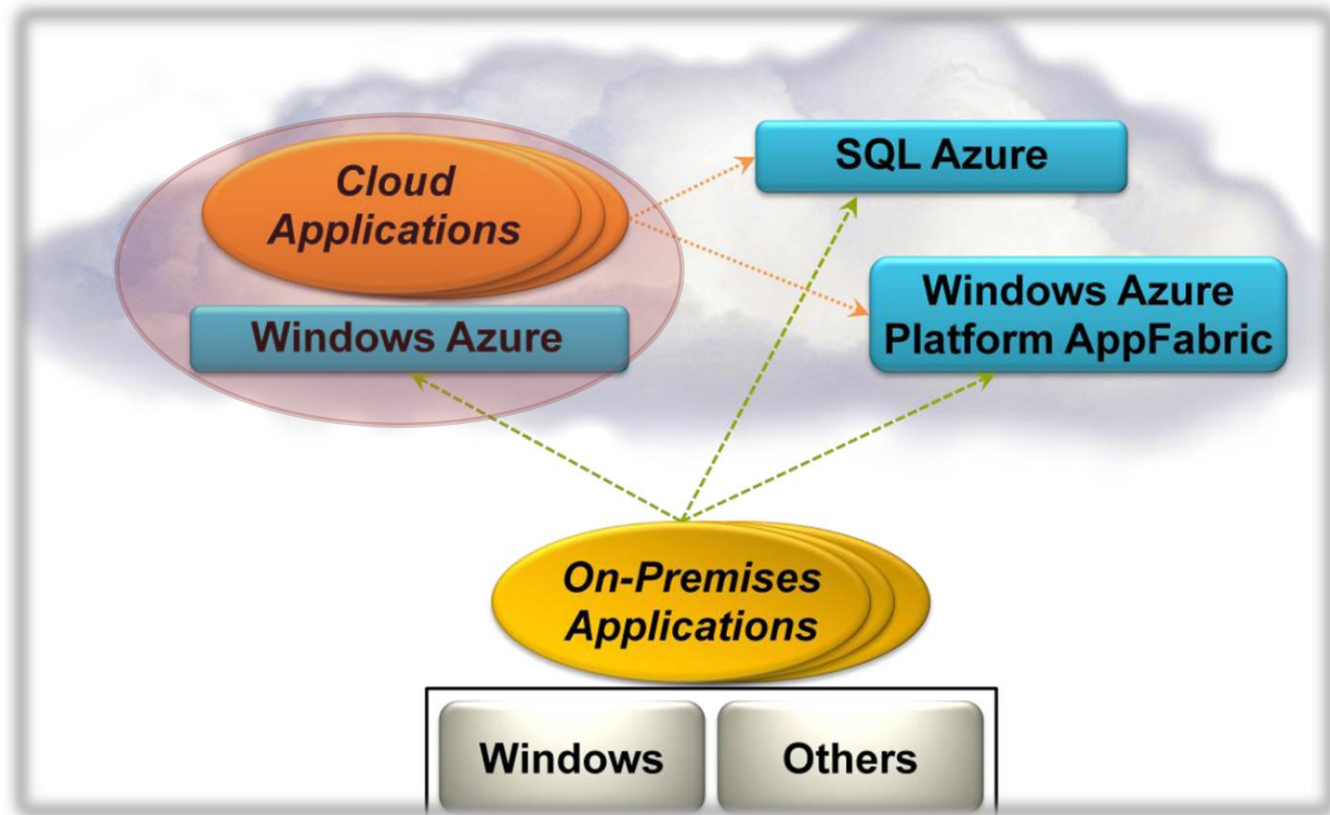
Windows Azure

SQL Azure

AppFabric

WINDOWS AZURE PLATFORM

Windows Azure

- Customers use it to run applications and store data on Internet-accessible machines owned by Microsoft

- Those applications might provide services to businesses, to consumers, or both

Businesses

Consumers

Internet

Applications

Data

Windows Azure

Microsoft Data Centers
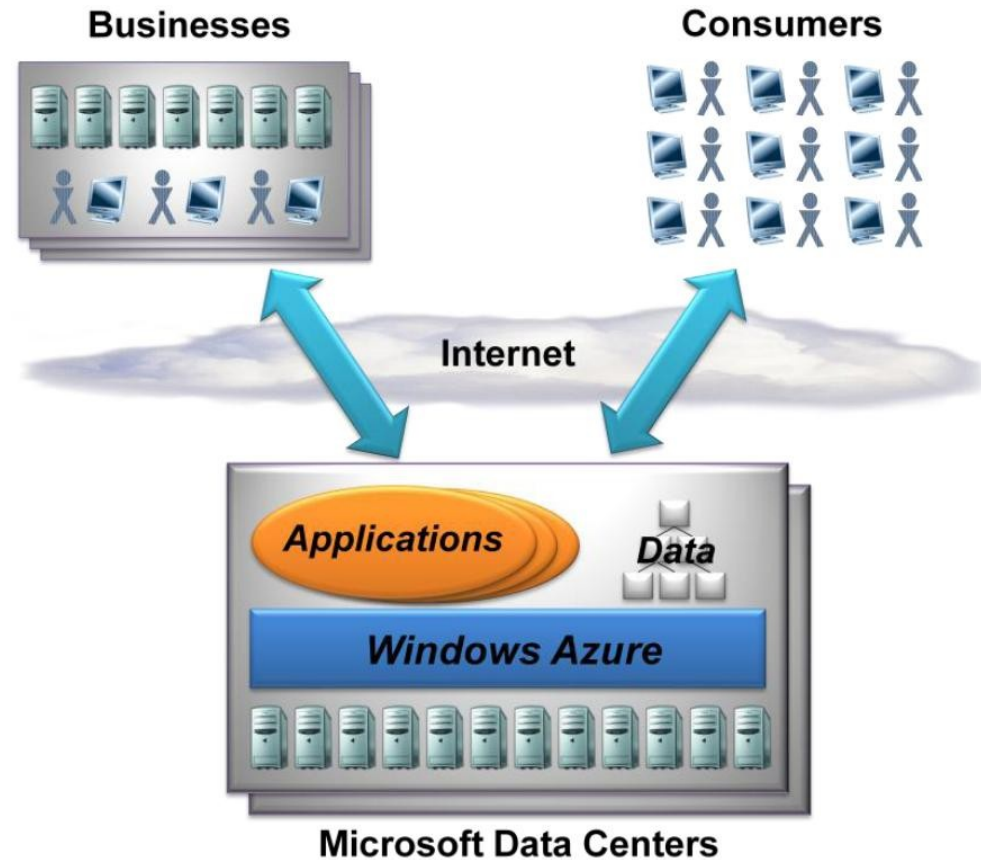
What is Windows Azure

- **Windows Azure** is a foundation for running Windows applications and storing data in the cloud
  - Provides Windows-based *compute* and *storage* services for cloud applications
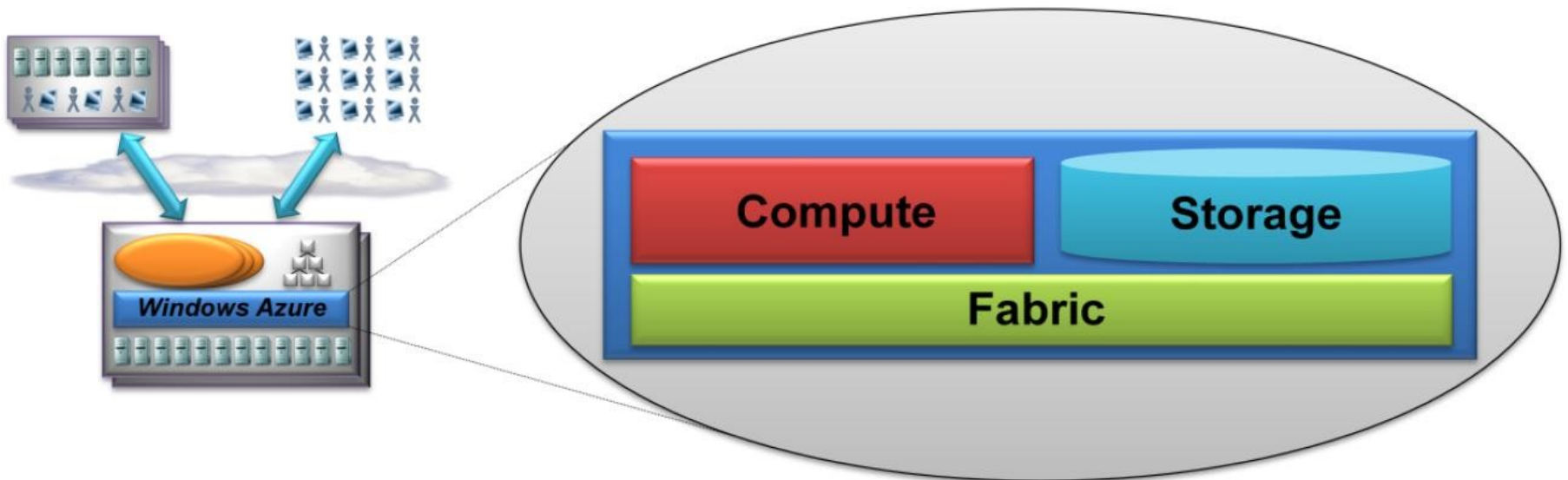
Components

- Compute
  - Running applications
  - Support applications that have a very large number of simultaneous users and that can scale out
- Storage
  - Storing and accessing data
  - Applications require storage as simple blobs, a more structured way to store information, or a way to exchange data between different parts of an application
- Fabric
  - Managing resources
  - Providing a common way to manage and monitor applications that use this cloud platform

Overview

Internet

Load Balancer

Windows Azure Data Center

Compute

Storage

Queue

Web role

Tables   Blobs

Compute

Worker role

Windows Azure Fabric

...

- Compute
- Storage
- Fabric

Windows Azure

Windows Azure - Compute

- In cloud computation, Windows Azure provides
  - Variety of services, like web service or background computation
  - A running environment of IIS 7 and .NET

- Four types of compute unit
  - A basic type provide single-core 1.66 GHz CPU, 1.75 GB of memory, and 225 GB of instance storage
  - Incremental by power of 2

Compute

- A Windows Azure application can have multiple *instances*, each executing in its own virtual machine (VM)

- Each VM is provided by a *hypervisor* (Hyper-V)

- A developer can create
  - A hosting account for running applications
  - A storage account for storing data
  - or both

- A developer can access
  - The instance through an interface
  - The Windows Azure portal through the Web browser

Instance Types

- Windows Azure provides two types of computation roles
    - Web role
        - A running environment that user can access
        - Web application service
    - Worker role
        - A environment runs particular processing
        - Ability to handle distributed or complicated tasks
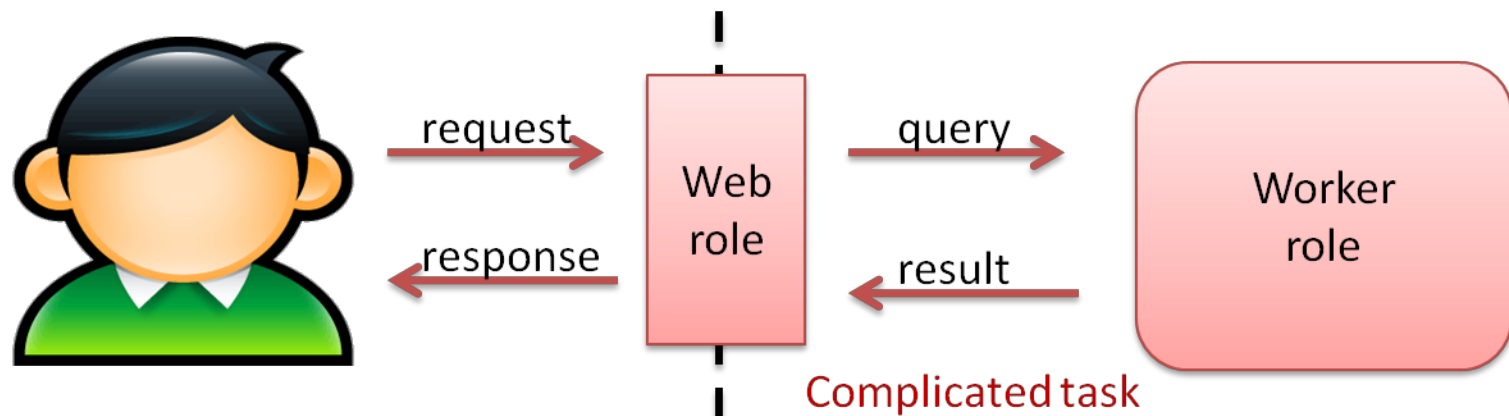
Instance Types

- Any service must include *at least one role* of either type, but may consist of any number of web roles or work roles

- Worker role can *communicate* with Web role using the Windows Azure storage *queues*

- Each VM contains an *agent* to allow the application to interact with the Windows Azure fabric

- Compute
- Storage
- Fabric

Windows Azure

Windows Azure - Storage

- In enterprise, it may need 10GB to 10PB storage space when company is growing

- Enterprise does not know how many disks is needed at initial

  - It could be underestimate or overestimate

- If underestimate
  - ⬜ Violate the contract and does not expand storage in time
- If overestimate
  - ⬜ Waste of resource and additional management costs

- Windows Azure can take care about the storage management
  - ⬜ Users do not need to worry about maintaining storage space, back-up and hardware fail
  - ⬜ Enterprises do not need to purchase the data center nor take the responsibility of maintenance only for a peak loads

- Windows Azure provides three type of storage and each one provides a special purpose
  - Blob
    - Provides blocks of storage that can store text or binary file
  - Table
    - Provides structured-based storage
  - Queue
    - Provides slices storages that support communication between applications

- Each type of storage service has its own limitation
  - Size of a file
  - Number of operations at once

Blob

- An account has his Blob storage, and can have multiple containers

- Each container has multiple Blobs, each can store blocks or pages
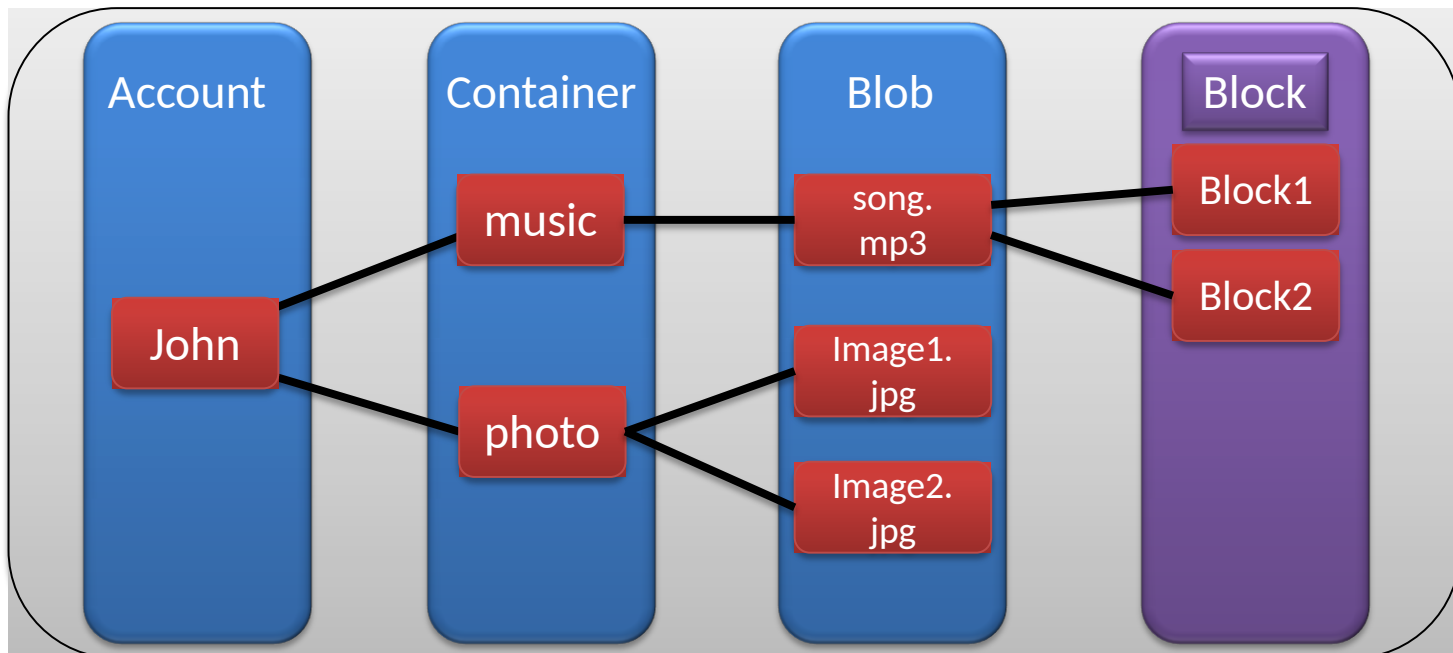
- Block Blob
   - Segment read/write
   - Identify by Block ID
   - Maximum size
      - 4MB for each block, and up to 50000 block

- Page Blob
   - Provided a Windows Azure Driver (aka X-Driver)
   - Random read/write
   - Identify by a range
   - Up to 1TB

X-Driver

- The underlying storage
- A mechanism for viewing persistent storage as if it were a local drive
- Implemented as a Windows Azure Page Blob containing an NTFS-formatted Virtual Hard Disk (VHD)

Table

- A simple structural data storage that can store some structural data
    - Similar to the EXIF information for describing a photo
- Table can be used as a lightweight database
- Entry is called as a line of data
- Every entry has a particular identifier which contains Account Key and Table Key

Table

- Account Name and Table Name are used to specify the account and table
- Partition Key is used to specify the same data on different partitions
- Row Key is an identifier of row data

Partition Key Class	Row Key Number	Property 1 Score 1	Property 2 Score 2	Table A
Class A	● No 1	A	A+	Partition 1
Class A	● No 2	B-	B-	
Class B	No 1	B+	A-	Partition 2
Class B	No 2	B+	B+	
Class B	No 3	A	A-	

entry

- Queue usually is used between application's communication

- A queue consists of some slices

- Each slice contains 8 KB data

- There is a particular process handling the queue, ensure each slice operator once
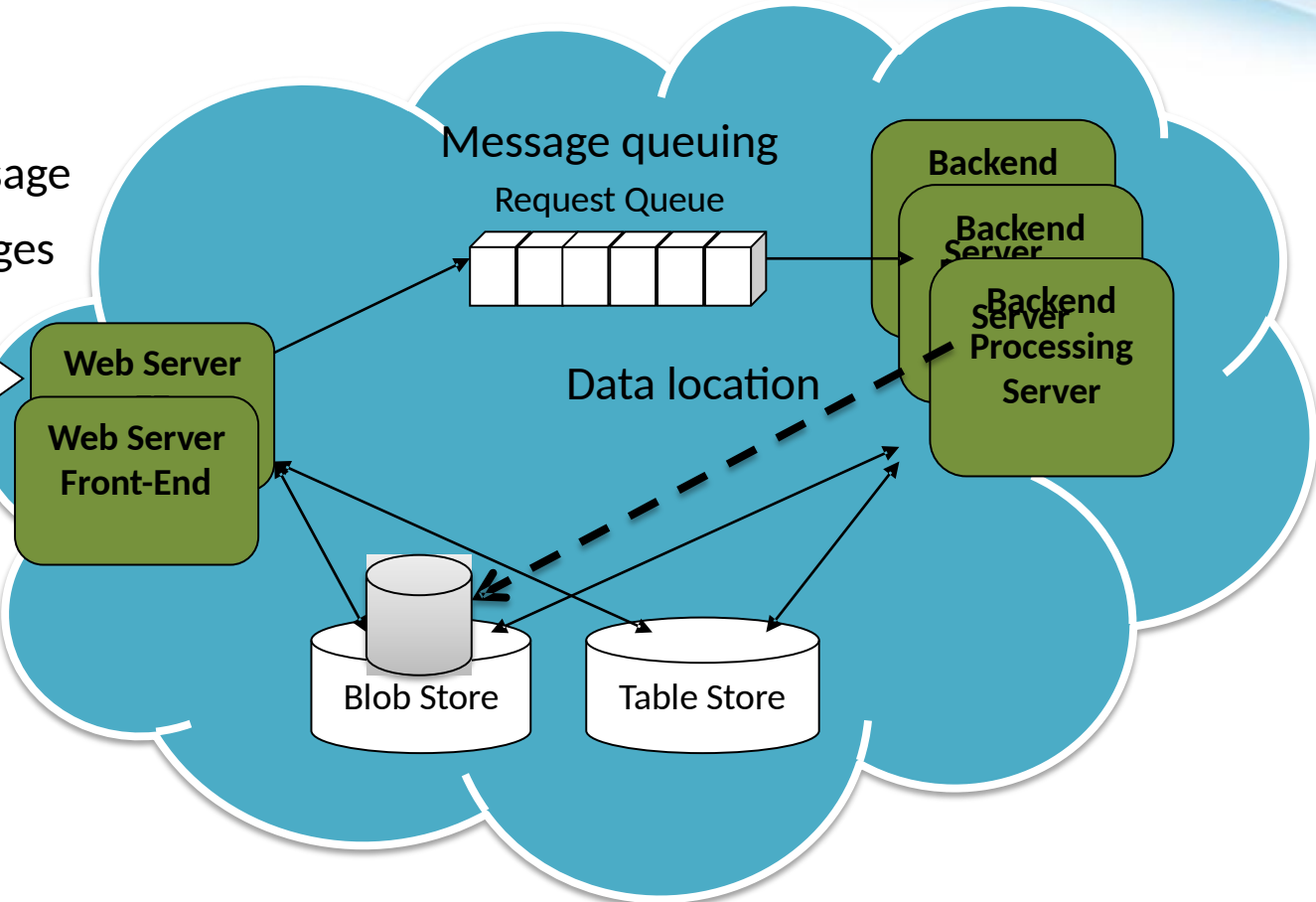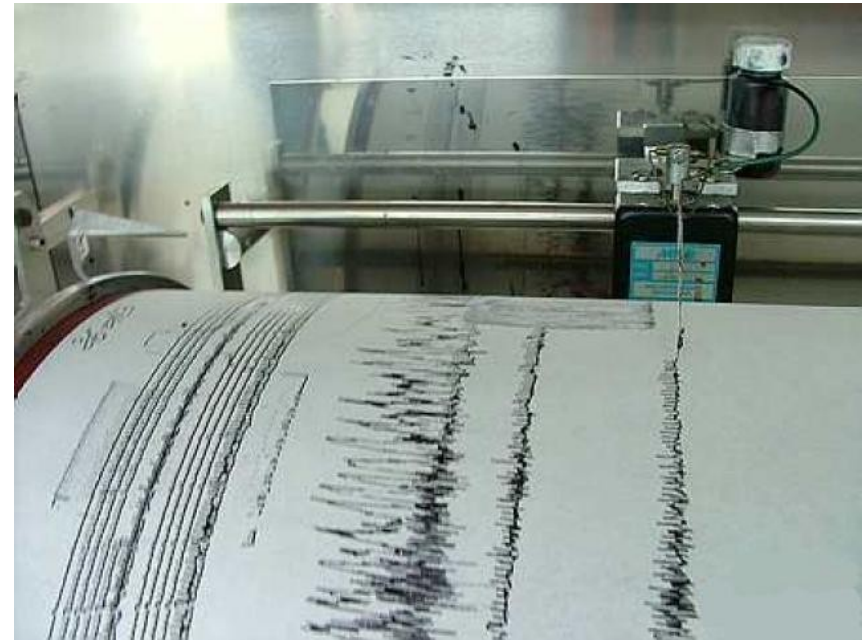
- Compute
- Storage
- Fabric

Windows Azure

Windows Azure - Fabric

- Windows Azure provides an automatic and autonomous way to manage resources
  - Automatically report and recode the status of machines
  - Provide a control center which can failure recover when one or many machines crash

Fabric Types

- Windows Azure supports two fabrics to control and management the machines and jobs
- Fabric Agent
  - Each one of virtual machine has one fabric agent
  - Report the status to fabric controller
  - Provide user's authentication and defense of attack
- Fabric Controller
  - Monitor and control the virtual machine by fabric agent
  - Manage the virtual machines, running environment and software configuration
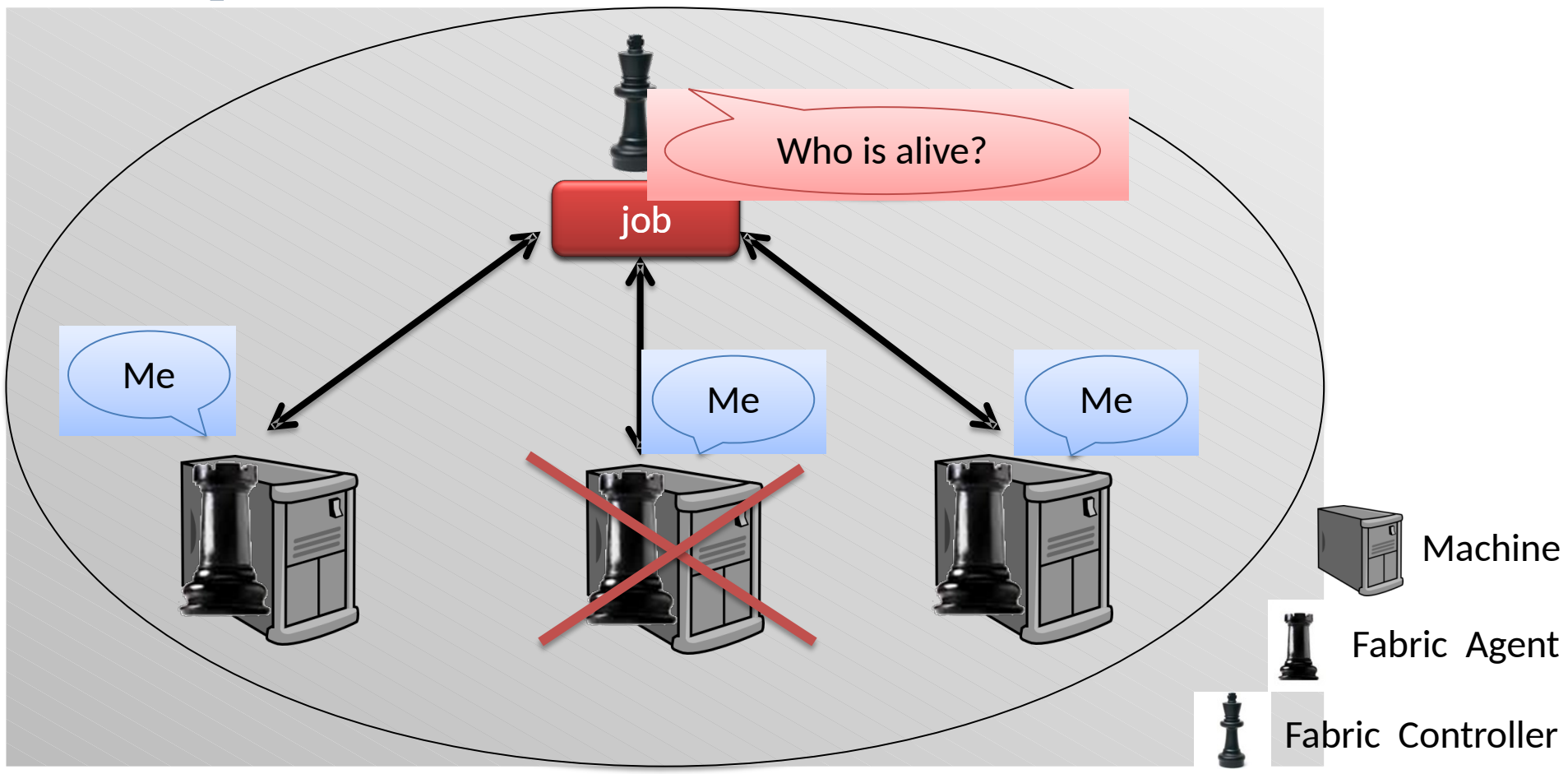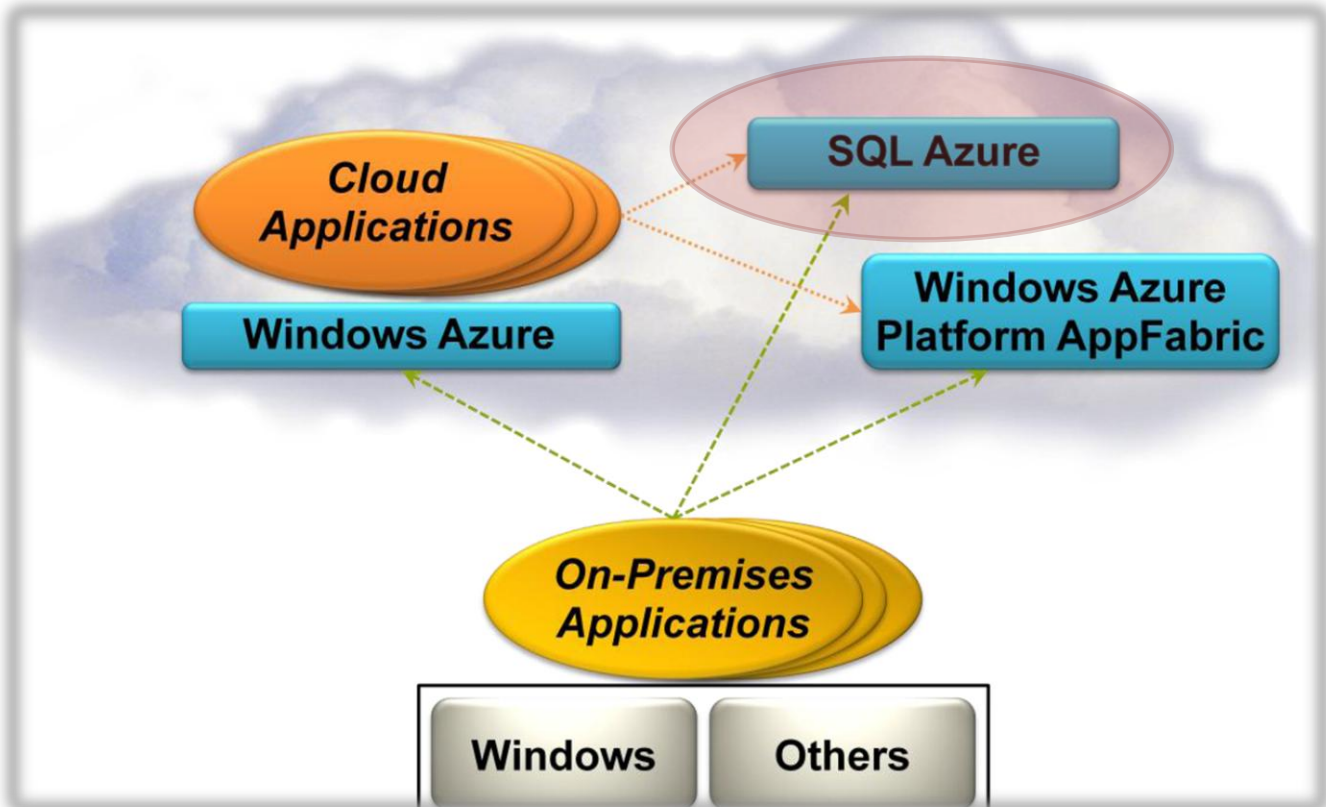 - Control the work flow

Example of Fabric

- The *fabric controller* interacts with Windows Azure applications via the *fabric agent*
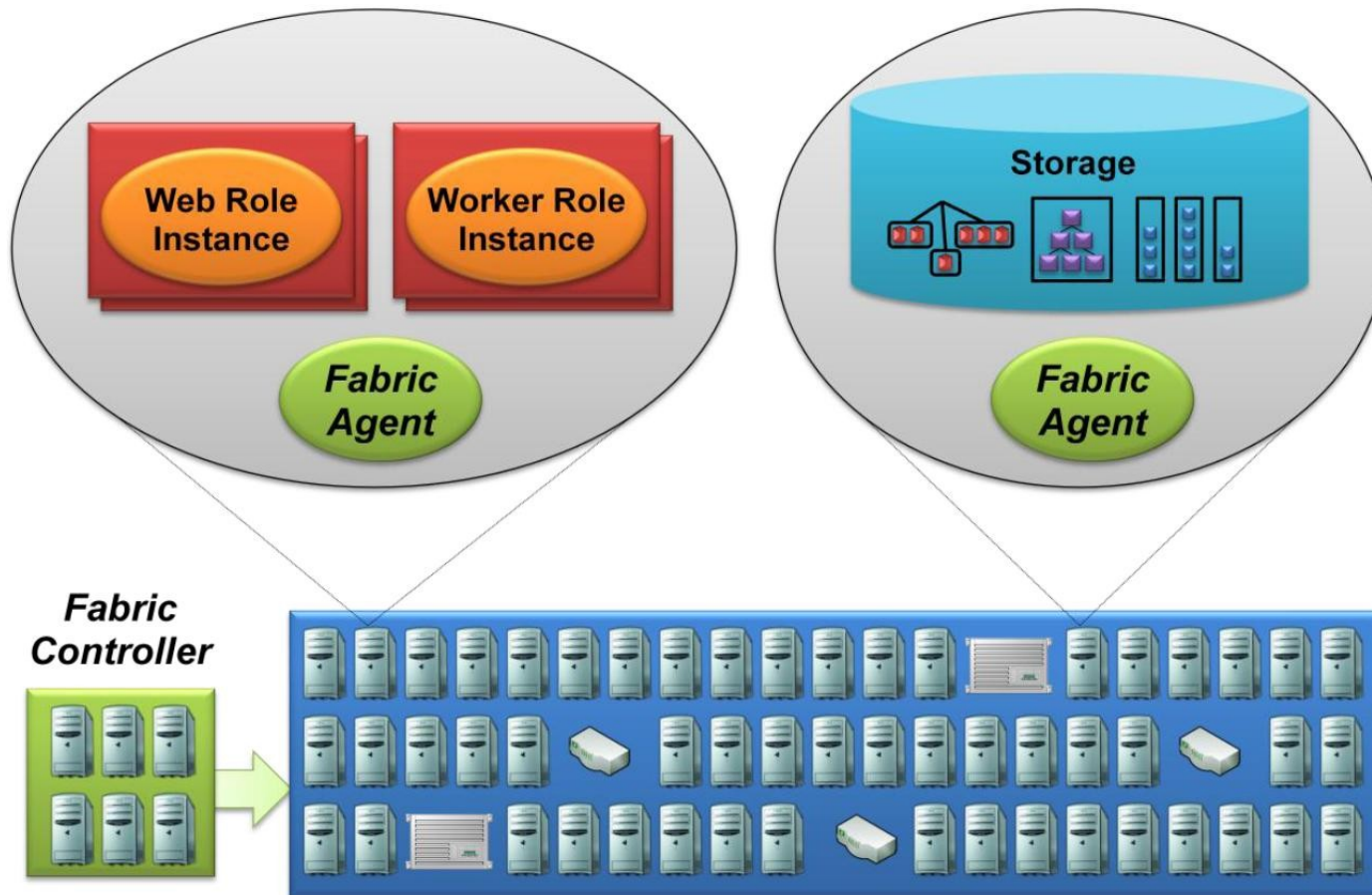
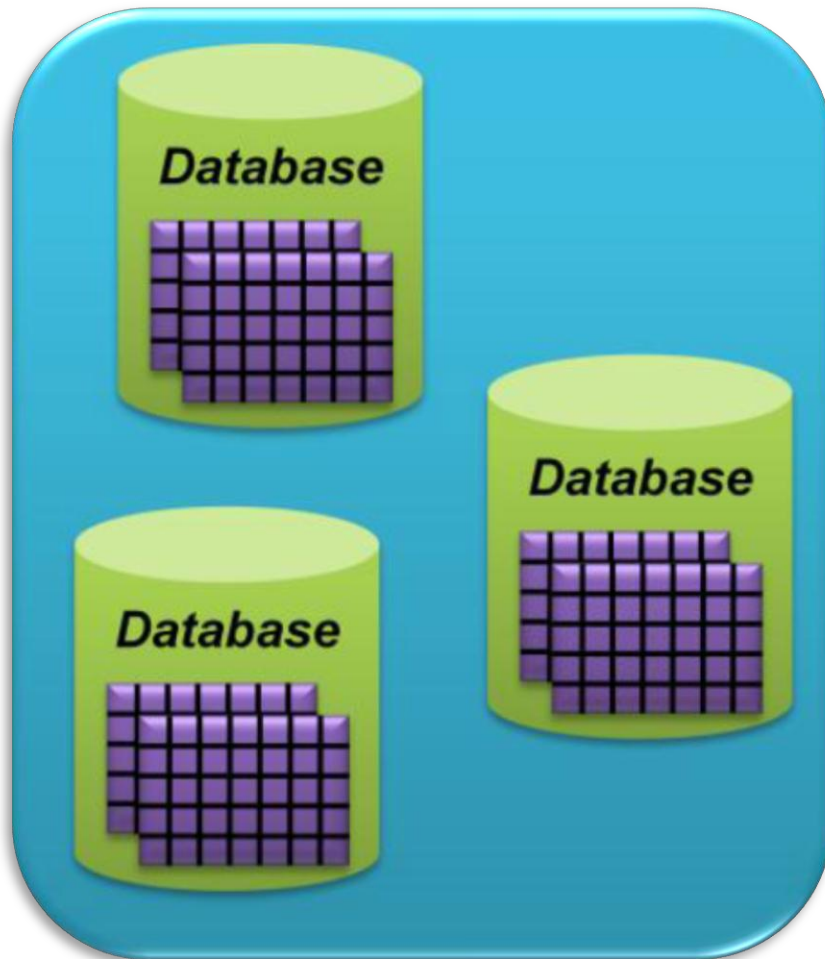- Fabric Agent records the status of machine and reports to Fabric Controller

Windows Azure

SQL Azure

AppFabric

WINDOWS AZURE PLATFORM
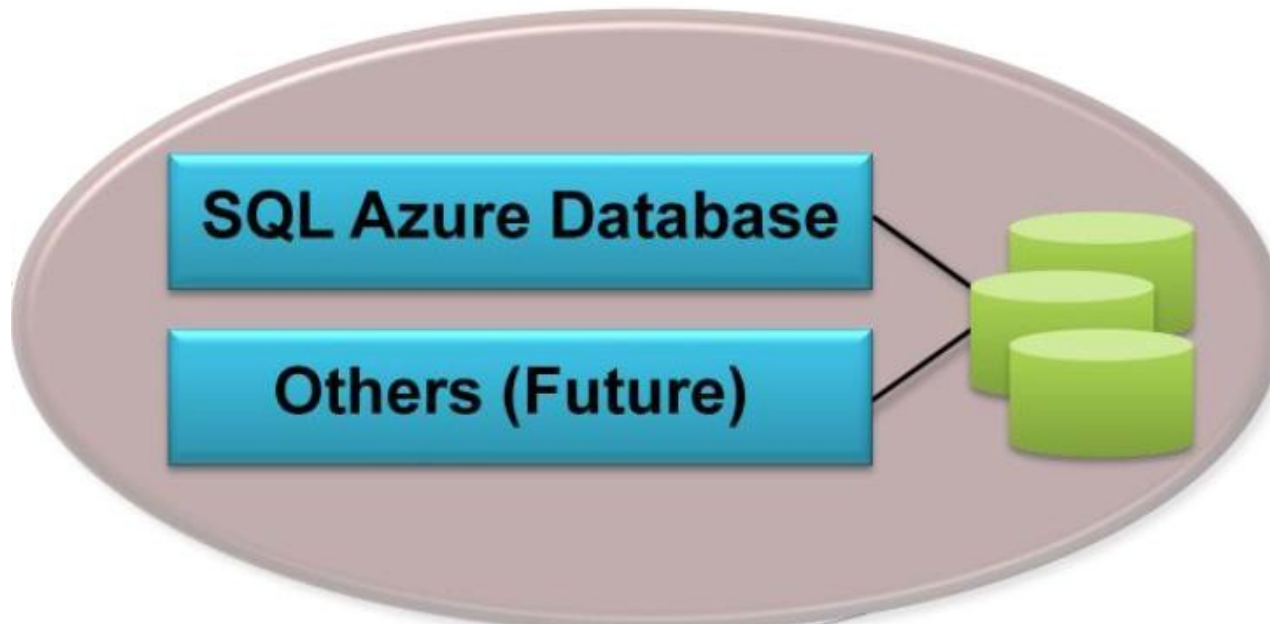
SQL Azure

- In many situations, enterprises or developers might need to find the relations between data

   - Enterprises need a database to store their critical and mass data

- Windows Azure Platform provides the SQL Azure to approach data services

- **SQL Azure** provides a cloud-based database management system (DBMS) and data-oriented services in the cloud
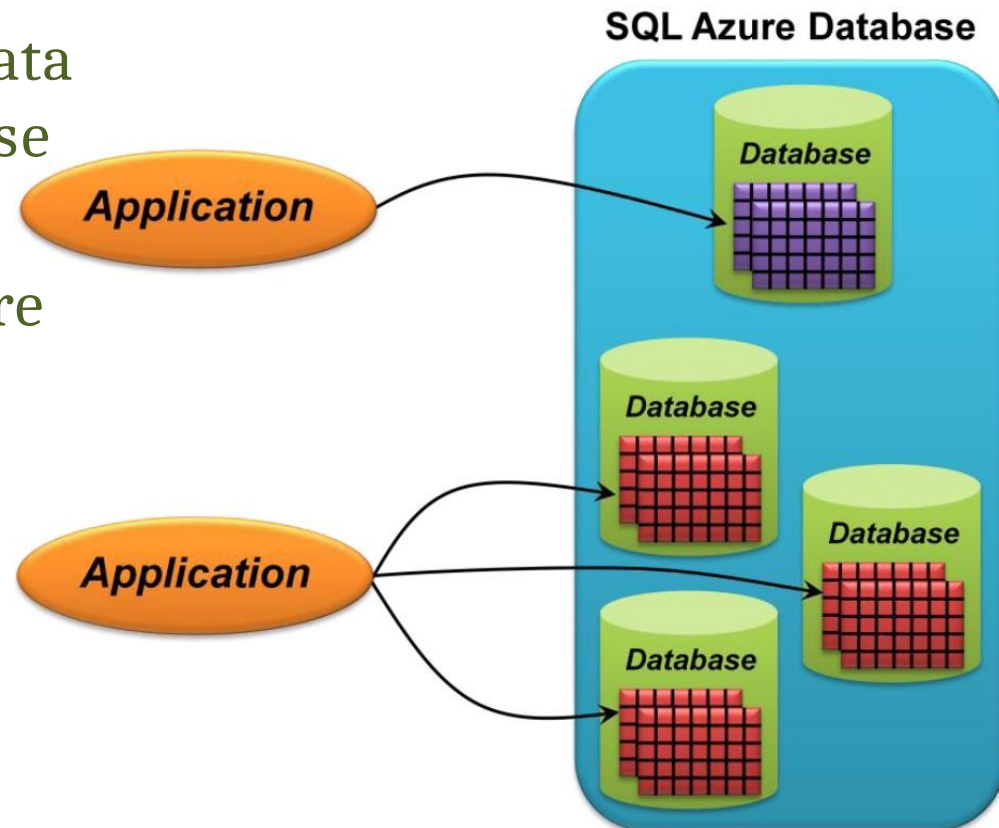
SQL Azure

- SQL Azure Database
  - A relational database
  - Supports Transact-SQL (T-SQL) language such that customers can use exist data model to develop services
  - Integrates with SQL Server, include Visual Studio, development tools
  - Reliable and scalable database on demand
- Limitation
  - A query can run for only a limited time
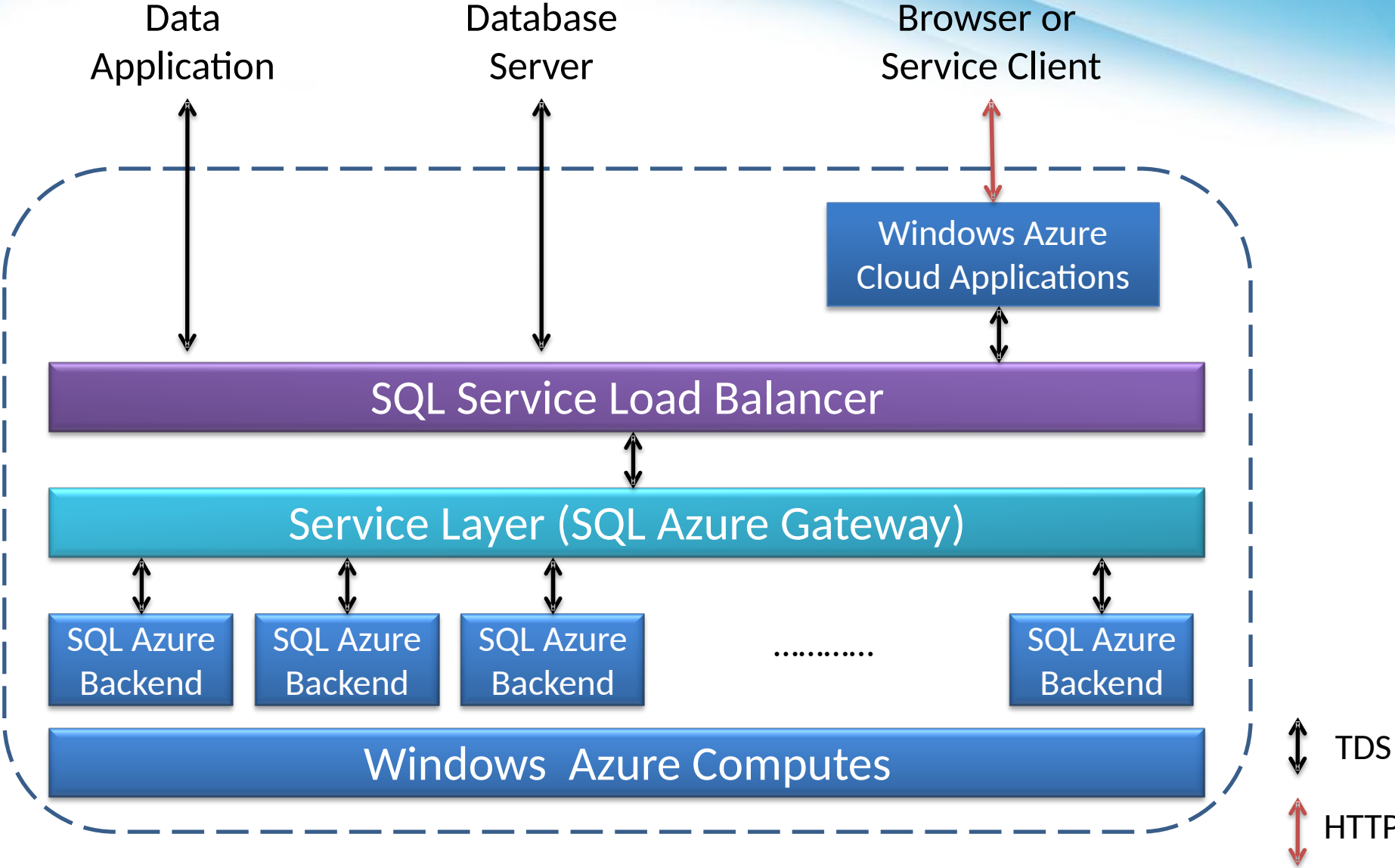 - The maximum size of a single database is 10 GB

SQL Azure Database

- An application can use a single database or multiple databases

  - An application whose data is within the limit can use just one database

  - An application with more data will need to create multiple databases

SQL Azure Database
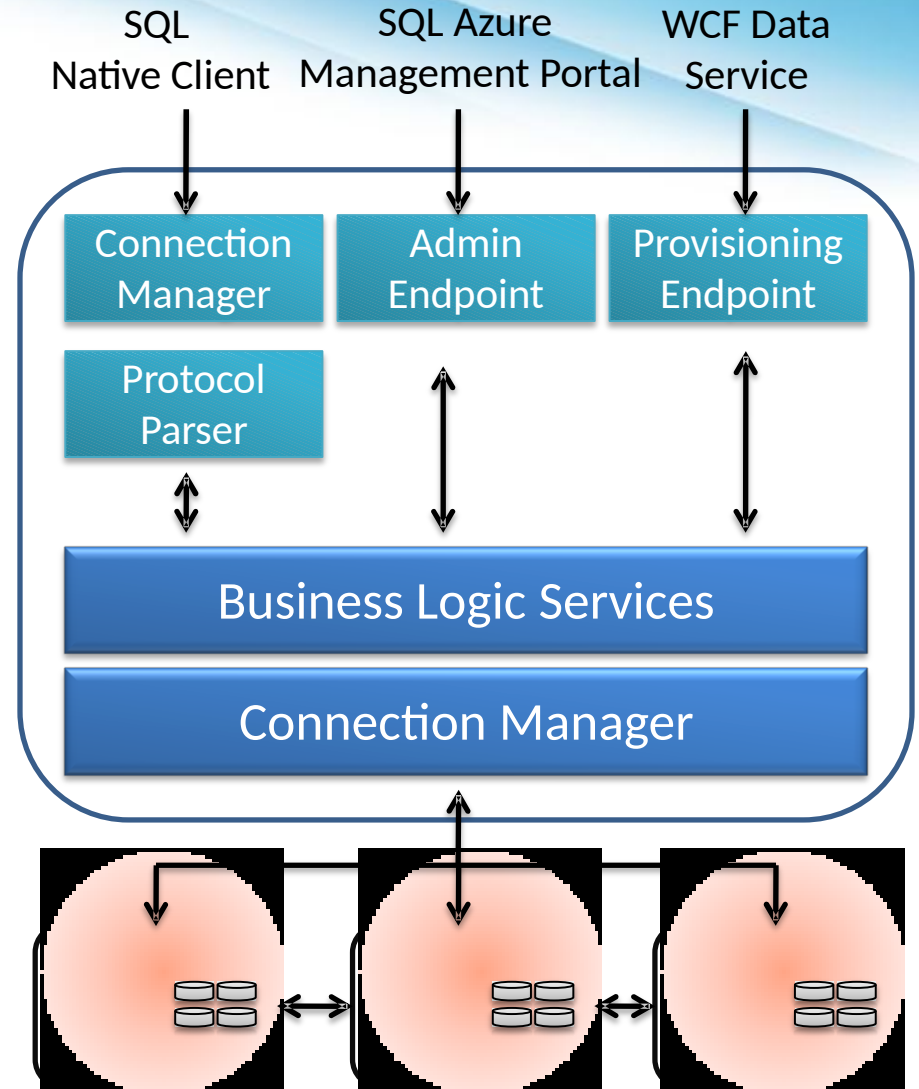
Application

Database

Application

Database

Database

Database

- Application can access the proper database which storing its data
  - Coordinate by the SQL Azure Fabric service
  - Link to a database via the connection routing
  - Do not care about the exactly location of database
- Each connection between application and SQL Azure could link to different database servers
  - Provide a high availability

SQL Azure Gateway

- SQL Azure Gateway is the critical component
  - Access data
  - Handle commands
- With the Gateway, user can ignore the detail of backend server
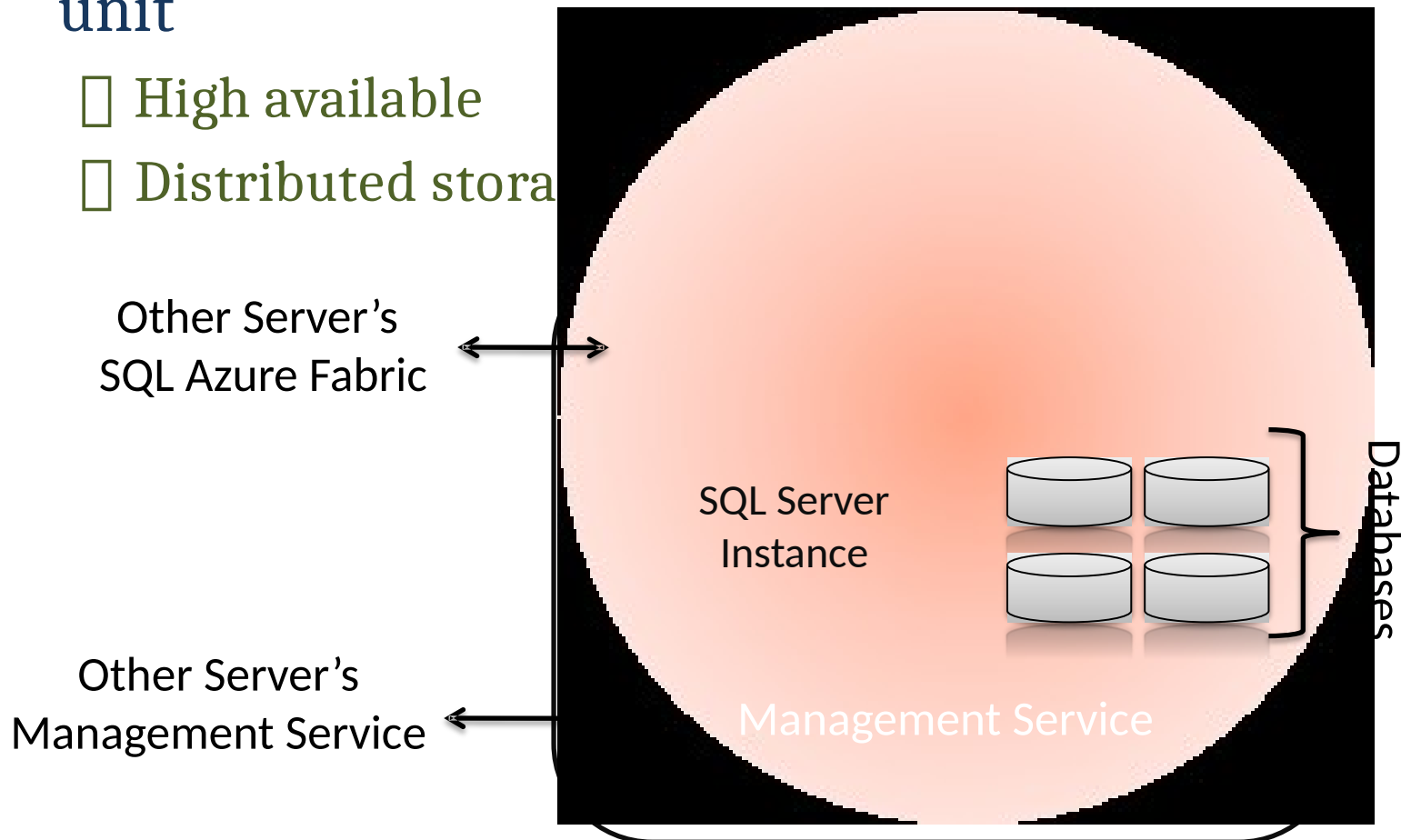 - Network topology
  - System deployment
  - Maintain method

SQL Native Client | SQL Azure Management Portal | WCF Data Service

Connection Manager | Admin Endpoint | Provisioning Endpoint

Protocol Parser

Business Logic Services

Connection Manager

SQL Azure Gateway

- Connecting to the gateway can access all functionalities on SQL Azure

- Gateway will check the TDS (a communication protocol used by SQL Server)
  - Analyze malicious commands
  - Authenticate the account
  - Billing

- Gateway redirects TDS to the backend server, and packs the result as a security TDS to client

- SQL Azure is build on Windows Azure's computes unit
  - High available
  - Distributed stora

Other Server's
SQL Azure Fabric

SQL Server
Instance

Databases

Other Server's
Management Service

Management Service

Backend Server

- SQL Azure Fabric manages databases that stores data in many SQL Azure nodes distributively
- SQL Azure Fabric controls the policy and frequency of data replication
    - Merge replication
    - Transactional replication
- Access any one of SQL Azure service can link to the proper database and get the correct data
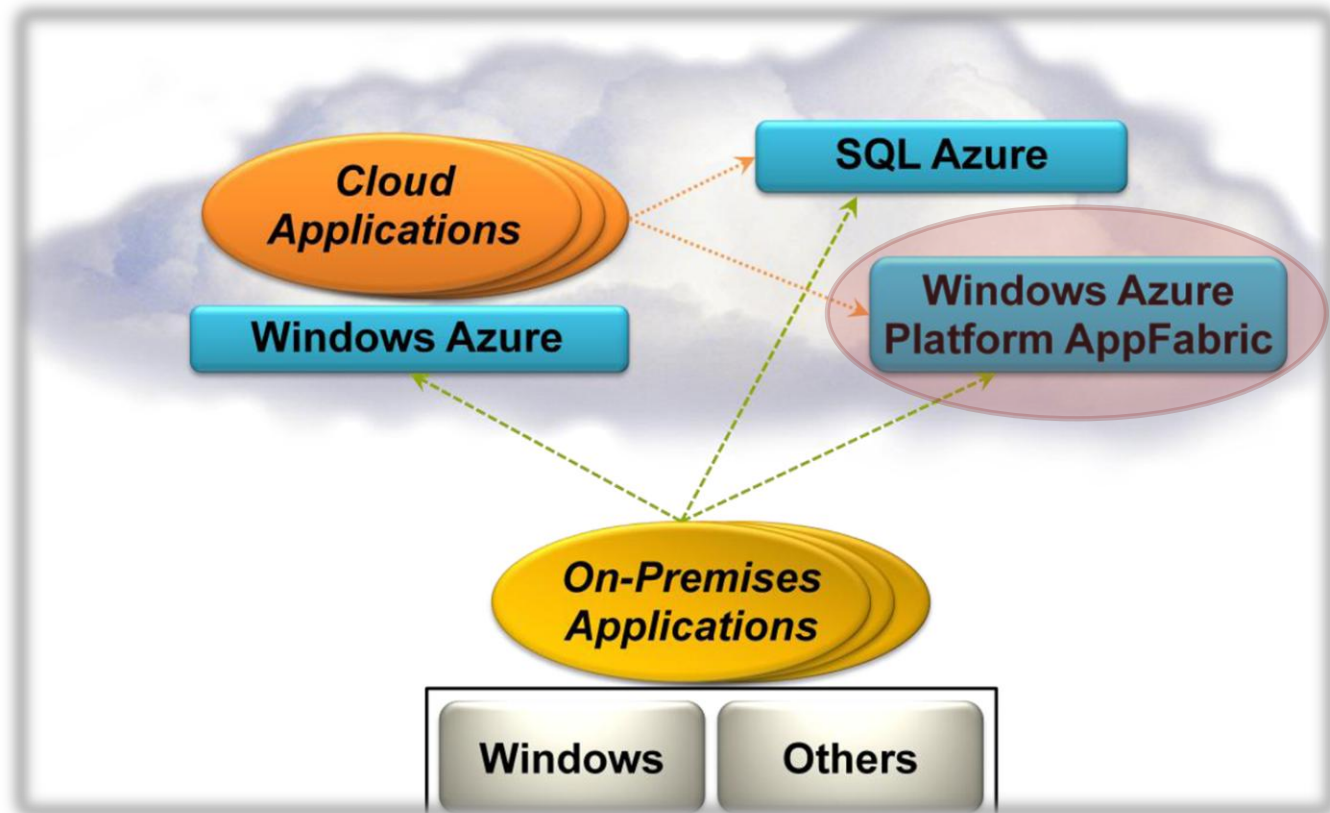
Windows Azure

SQL Azure

AppFabric

WINDOWS AZURE PLATFORM

- **AppFabric** provides cloud-based infrastructure in connecting distributed services and applications

Windows Azure Platform AppFabric: Service Bus, Access Control

AppFabric

- ## What AppFabric can do
  - Make connections between applications possible
  - Provide a service application for enterprise-level architecture
  - Based on open communication and standard of service, venders provide the concept of service reusability

- ## Components
  - Service Bus
    - Makes connection simpler by letting an application expose endpoints that can be accessed by other applications
  - Access Control
    - Provides the ability for applications with authentication and authorization
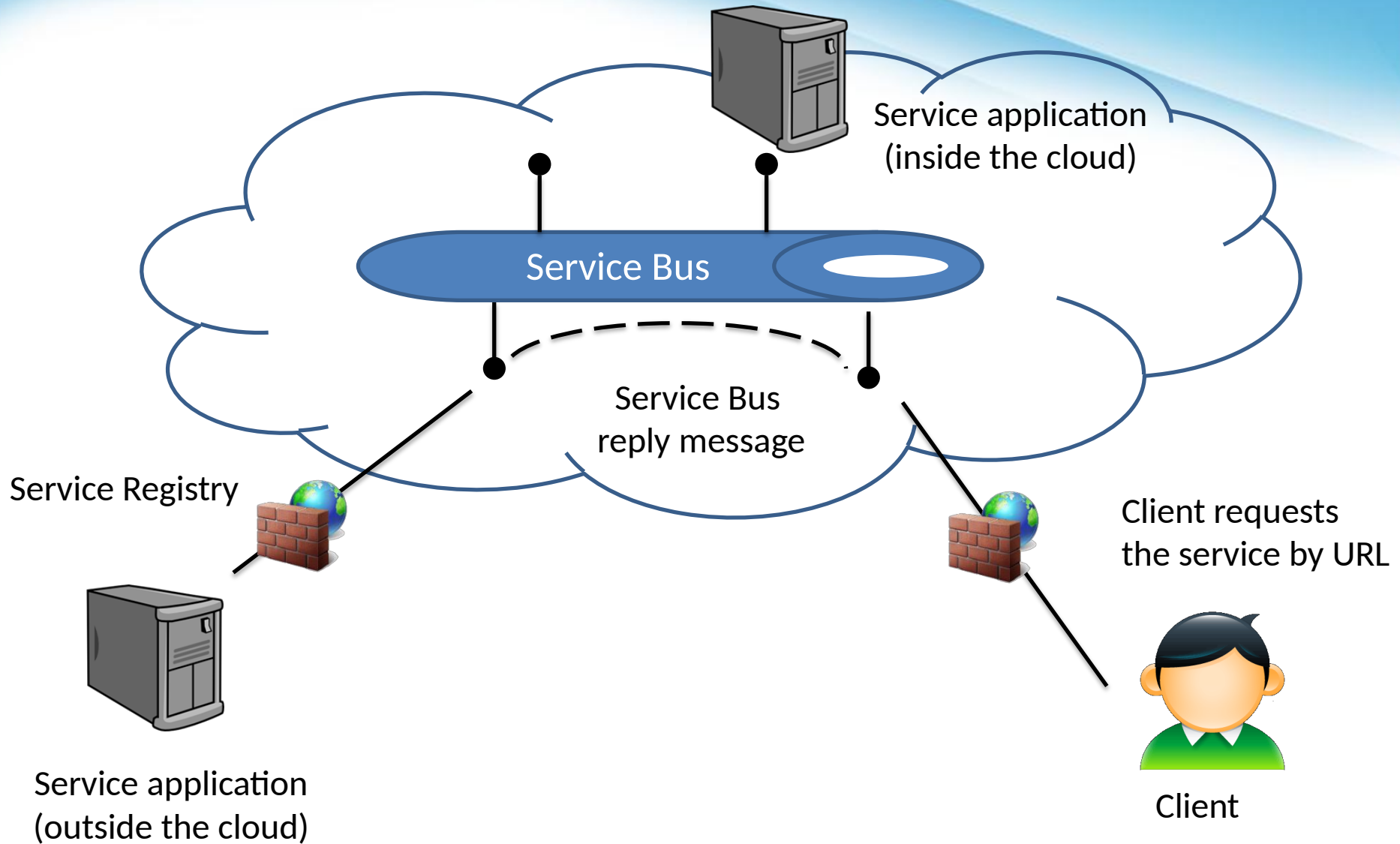
Service Bus

- Service provider can register endpoints with Service Bus
- Service consumer can discover and use those endpoints to access the service
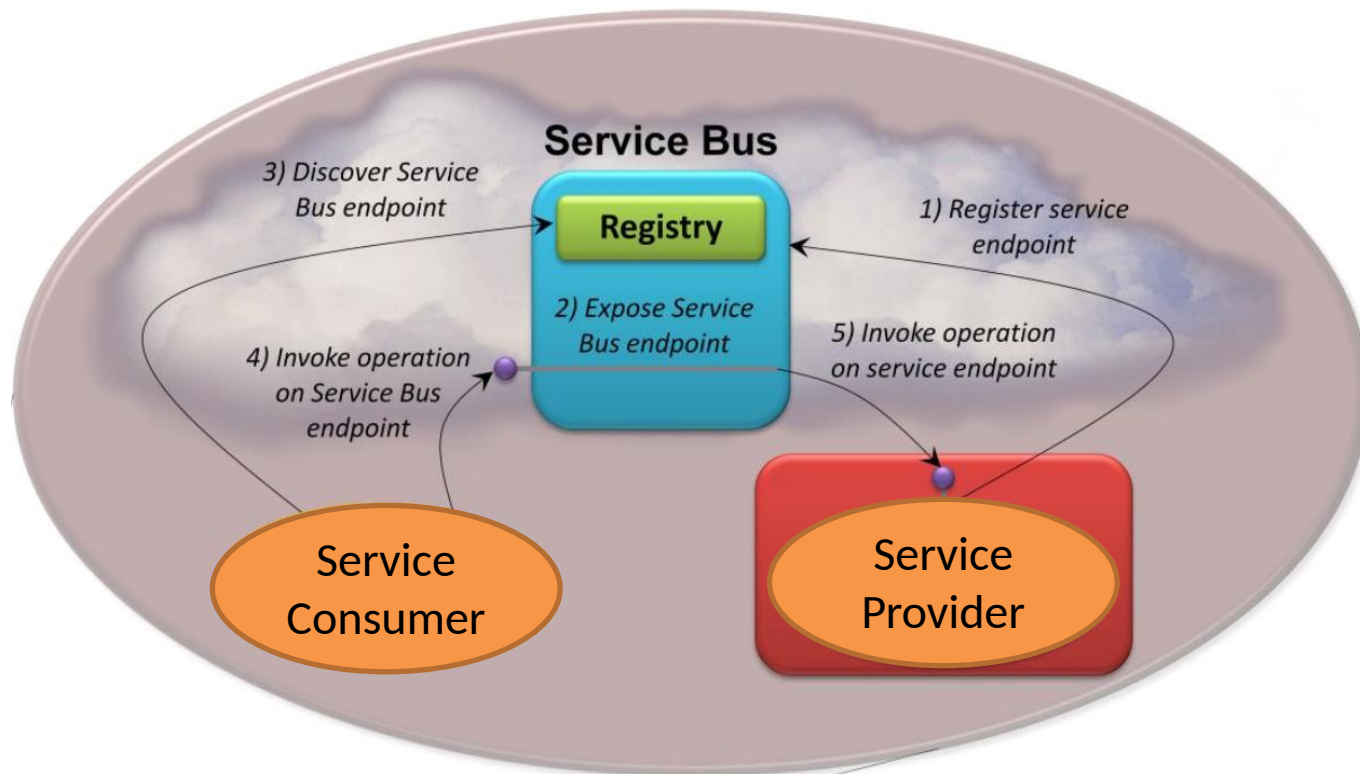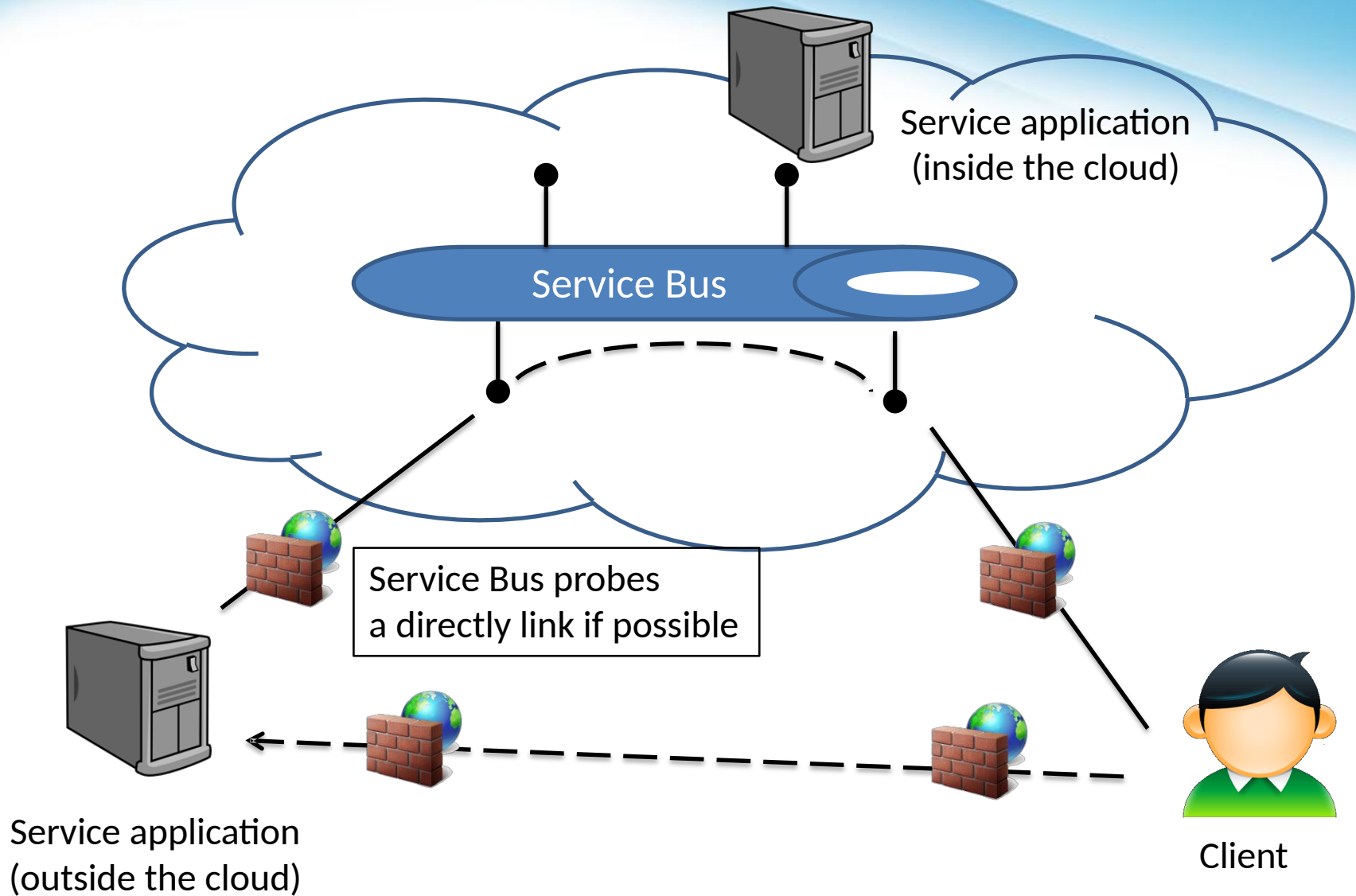
- AppFabric Service Bus supports two types of communication mechanisms according to client application
    - Message reply
    - Directly connect
- Client application can set the Hybrid connection mode
    - Try to use directly connect
    - If Service Bus does not detect the direct connection, use the message reply

Message Reply

Service application
(inside the cloud)

Service Bus

Service Bus
reply message

Service Registry

Service application
(outside the cloud)

Client requests
the service by URL

Client

Directly Connect

Service application
(inside the cloud)

Service Bus

Service Bus probes
a directly link if possible

Service application
(outside the cloud)

Client

Access Control

- Access Control service helps applications authenticate and receive identity information about their client applications
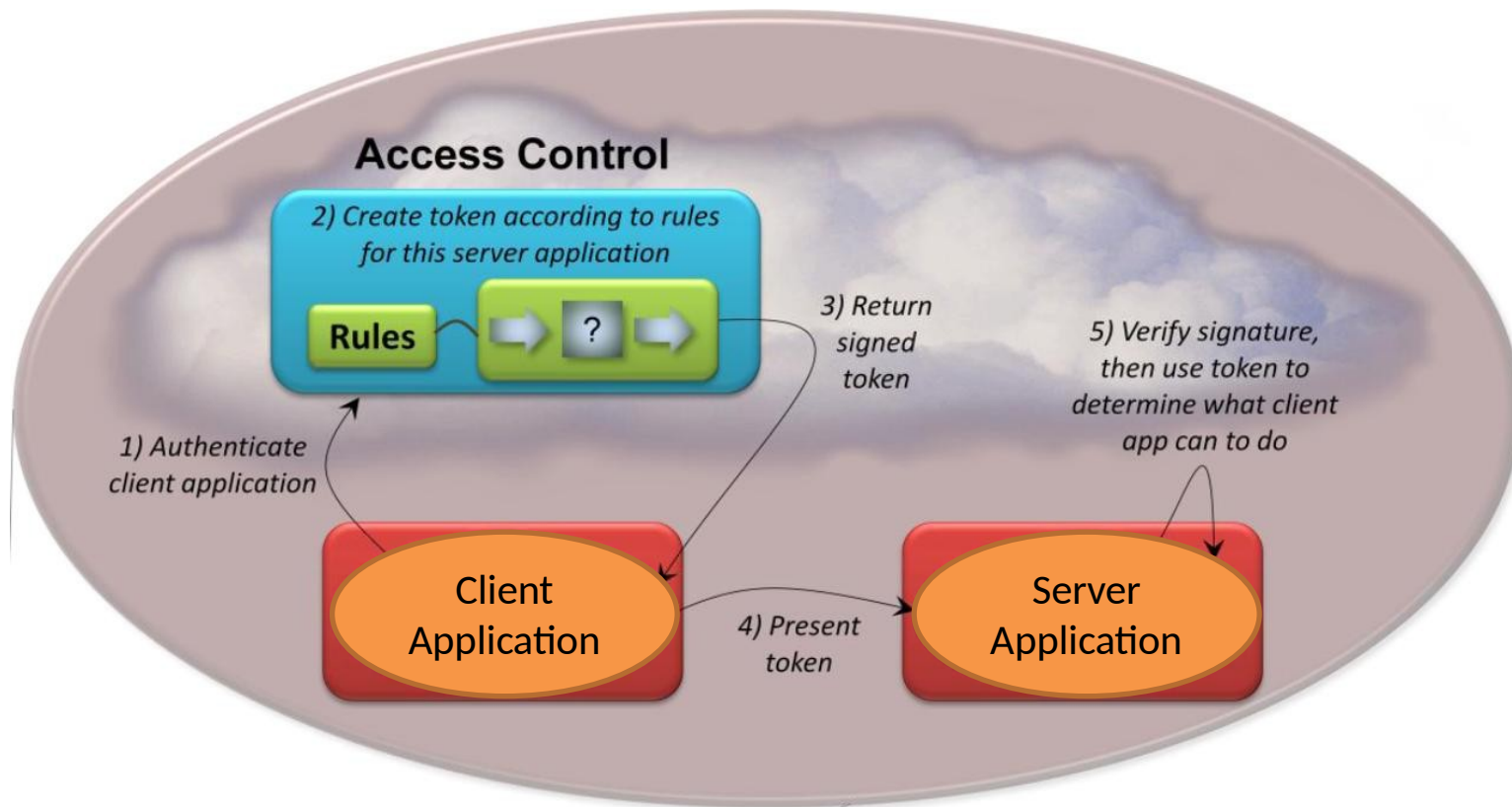
Access Control

- Access control is a Single Sign-On (SSO) service for service bus

  - User accesses the service bus must be authenticated by the access control

- User only needs a token when access multi-services

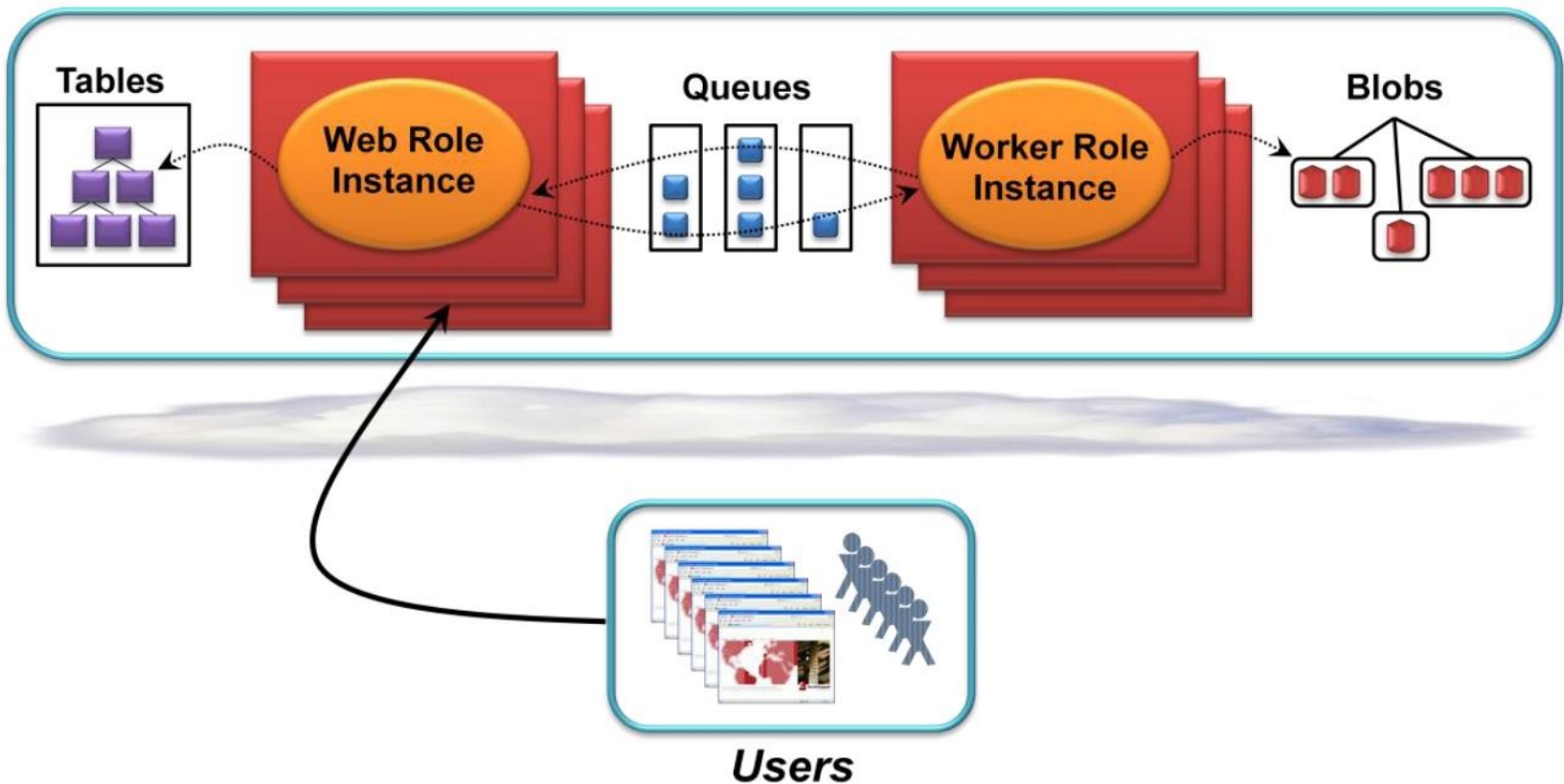 - The token can be recognized for multi-services in a period of time

Scenarios

- Creating a web application with background processing
- Using cloud storage from an on-premises or hosted application

Windows Azure Platform

- Web application with background processing
  - Scalable
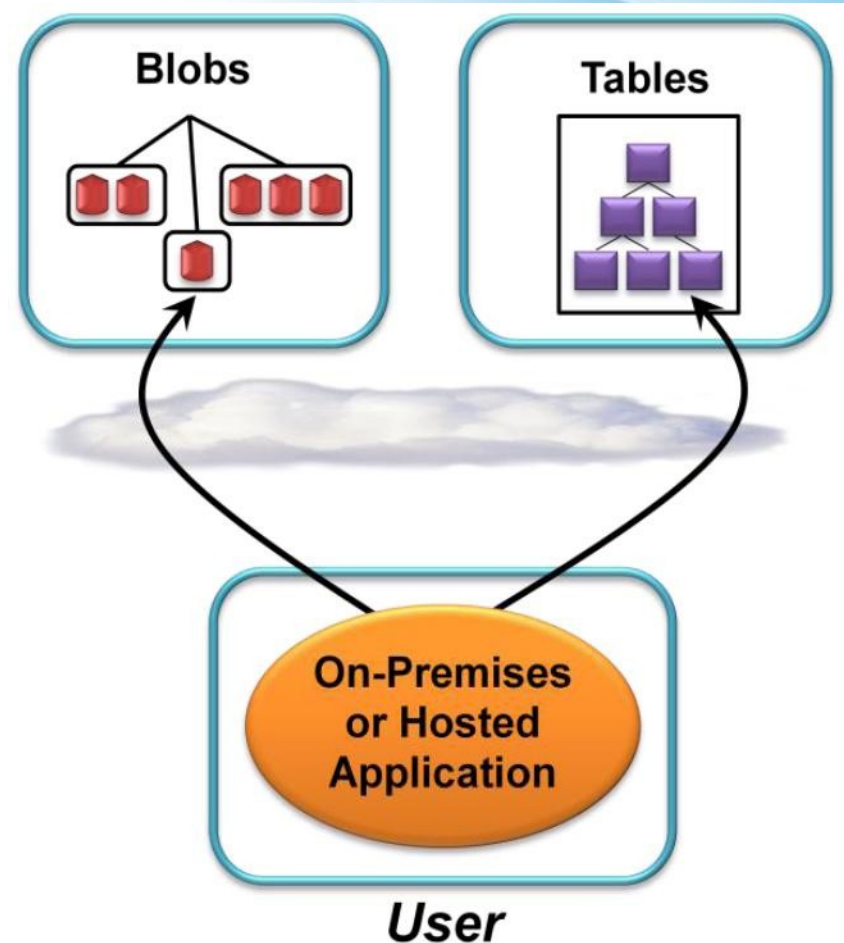 - Support a large number of simultaneous users

Scenario 2

- An on-premises or hosted application can use Blobs and Tables to store its data in the cloud

    - Access is likely to be slower, but
        - Cheaper
        - Scalable
        - Reliable

- Microsoft Windows Azure platform could
    - Support applications, data, and infrastructure in the cloud
    - Provide a subset of SQL server's functionality to support the relational database and SQL-like queries
    - Create an application whose code and data can exist either on-premises or in the cloud
    - Charge based on your usage
    - Guarantee
    - …

Guarantee	Rate
External connection	99.95%
Web / Worker role process	99.9%
Success of insert, update, delete data	99.9%
Access of SQL azure	99.9% (per month)

Properties & Characteristics

- Scalability
  - Provide scale-out compute/storage capability of handling very large amounts of application/data
- Availability
  - Provide the ability of failure tolerance such that application or service would not stop on failure
- Manageability
  - Let applications run continuously while minimizing the administrative effort required
    - In particular, customers do not worry about Windows patches
- Performance
  - Provide load balancing to spread request across Web role instances and support parallel processing with Worker role instances
- Accessibility
  - Control and monitor running instances through the web portal or the programming APIs

References

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  - 小朱 *Windows Azure* 教戰手札：您必須學會的微軟雲端開發技術,碁峰 2010
- All resources of the materials and pictures were partially retrieved from the Internet