01 Introduction to Cloud Computing

Course Objectives

- At the end of this course, you will have a better understanding of:
  - The history of data centers
  - The features of cloud computing
  - Cloud computing technologies
  - The impact and market of cloud computing
  - Tencent Cloud

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Chapter I The Evolution of Data Centers

1.1 Self-built EDCs/IDCs

1.2 Rented/Hosted IDCs

1.3 Cloud Computing

1.4 EDCs, IDCs, and Cloud Computing

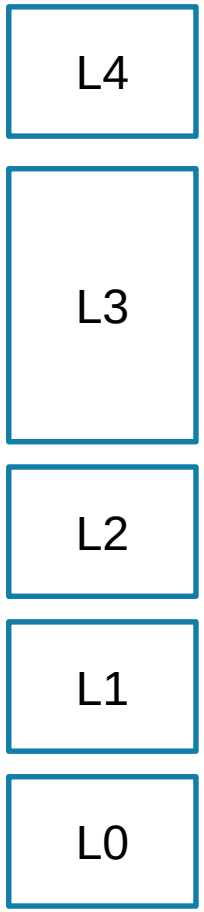
1.1 Enterprise Data Centers (EDCs)

- **Challenges:**
  - Difficult to build, involves complex Ops management
  - Hard to scale and make adjustments, involves long launch cycle
- **High TCO**

TCO = CapEx + OpeEx + OppCost

- **Uncertain TVO**

TVO = Business value and benefits from IT



Data Center Layers: L0-L4

Business Application Layer
Various application systems (ERP, CRM, OA systems, etc.)

Application Support Layer
Middleware, messaging, integrated development environment, and APIs/SDKs

Data Analysis Layer
Databases, data warehouses, and BI systems

IT Infrastructure Layer
Servers, networks, storage, and information security

Facility layer
Power supply, cooling, cabinets, and cabling

Housing Layer
Buildings, logistics, site security, and fire prevention

1.1 Enterprise Data Centers (EDCs)

- **IDC Tiers: T1-T4**
  - Reliability and security
  - OPS management capabilities
  - Infrastructure availability

$$\text{Availability} = \frac{\text{Promised service time} - \text{downtime}}{\text{Promised service time}} \times 100\%$$

- **Tencent Cloud data centers must be above T3**

Uptime Institute

DC Tier	Description	Availability	Annual Downtime
T4	Active/active fault tolerance	99.995%	0.8 h
T3	Parallel maintenance	99.982%	1.6 h
T2	Redundant components	99.741%	22.0 h
T1	Basic capacity	99.671%	28.8 h

1.1 Self-built Internet Data Centers (IDCs)

All the work needs to be done by the enterprise itself:

Planning and construction: IDC design, civil engineering...

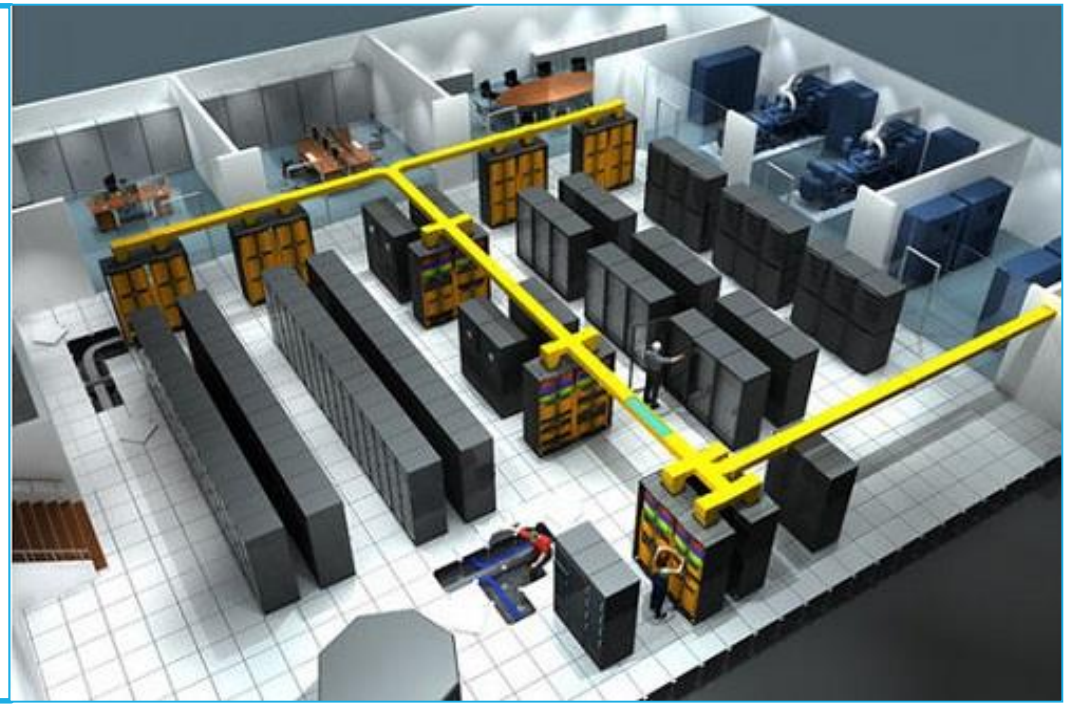
Deployment: servers, storage...

Ops: monitoring, alarming, security Ops...

Business system deployment, security Ops, availability, and reliability

Disadvantage:

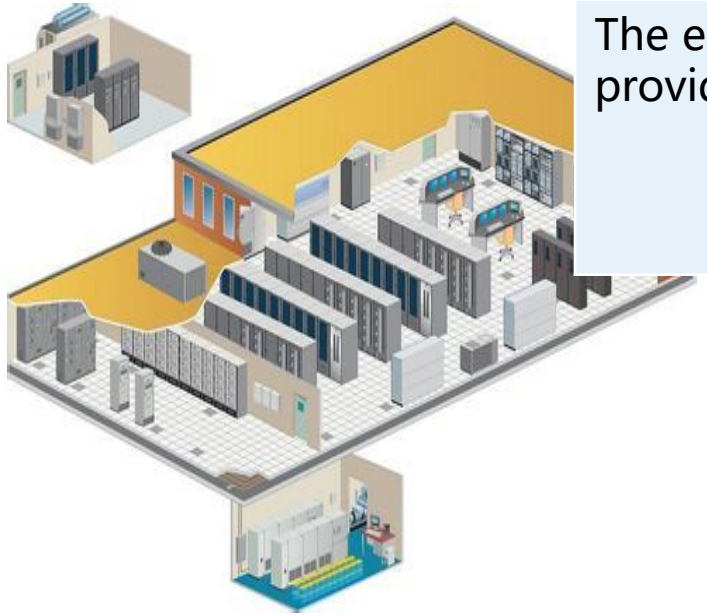
High costs



What are the challenges involved in self-built IDCs?

1.2 Hosted/Rented IDC

- Two types of leasing of IDC resources such as storage, servers, and bandwidth: **hosting and renting**
- **Advantages of hosted/rented IDCs over self-built EDCs:**
  - Lower costs
  - Faster IDC launch
  - Carrier-grade reliability
  - Standardization
  - Ops management



Responsible Entity	Hosted	Rented
The ISP provides:	Facilities Bandwidth Power	Facilities Bandwidth Power Hardware Management Maintenance
The enterprise provides:	Hardware Management Maintenance Business systems	Business systems

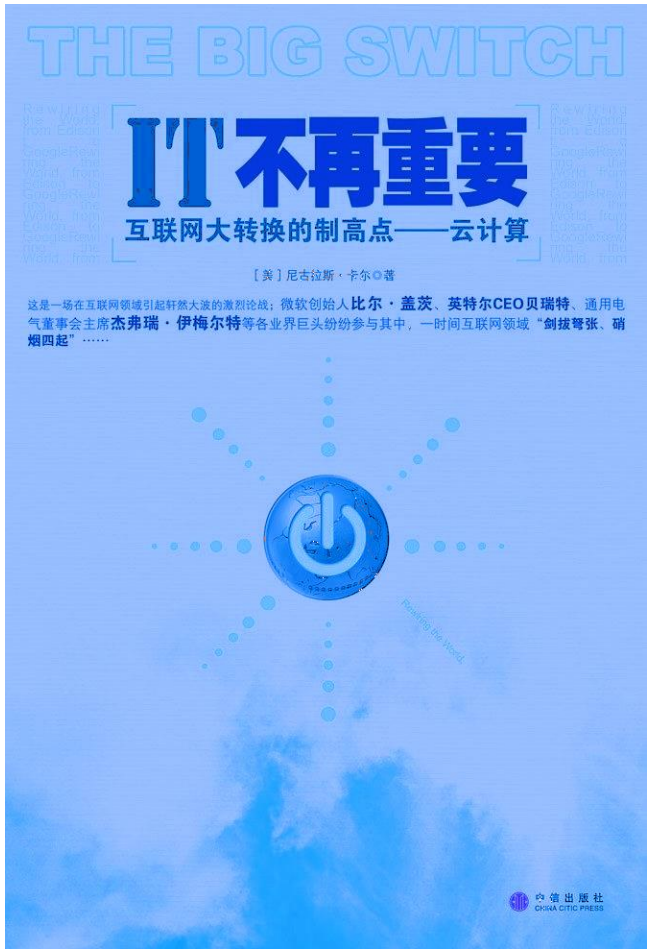
1.3 Cloud Computing: Service on Demand, Pay-as-you-go

- **Origin**: More and more, companies will fulfill their IT requirements simply by purchasing fee-based “Web services” from third parties—similar to the way they currently buy electric power or telecommunications services.

  – IT Doesn't Matter, Nicholas Carr, 2003

- **Proposal:** In 2006, Google CEO Eric Schmidt proposed the concept of cloud computing. AWS was founded in 2006, marking the birth of cloud computing.

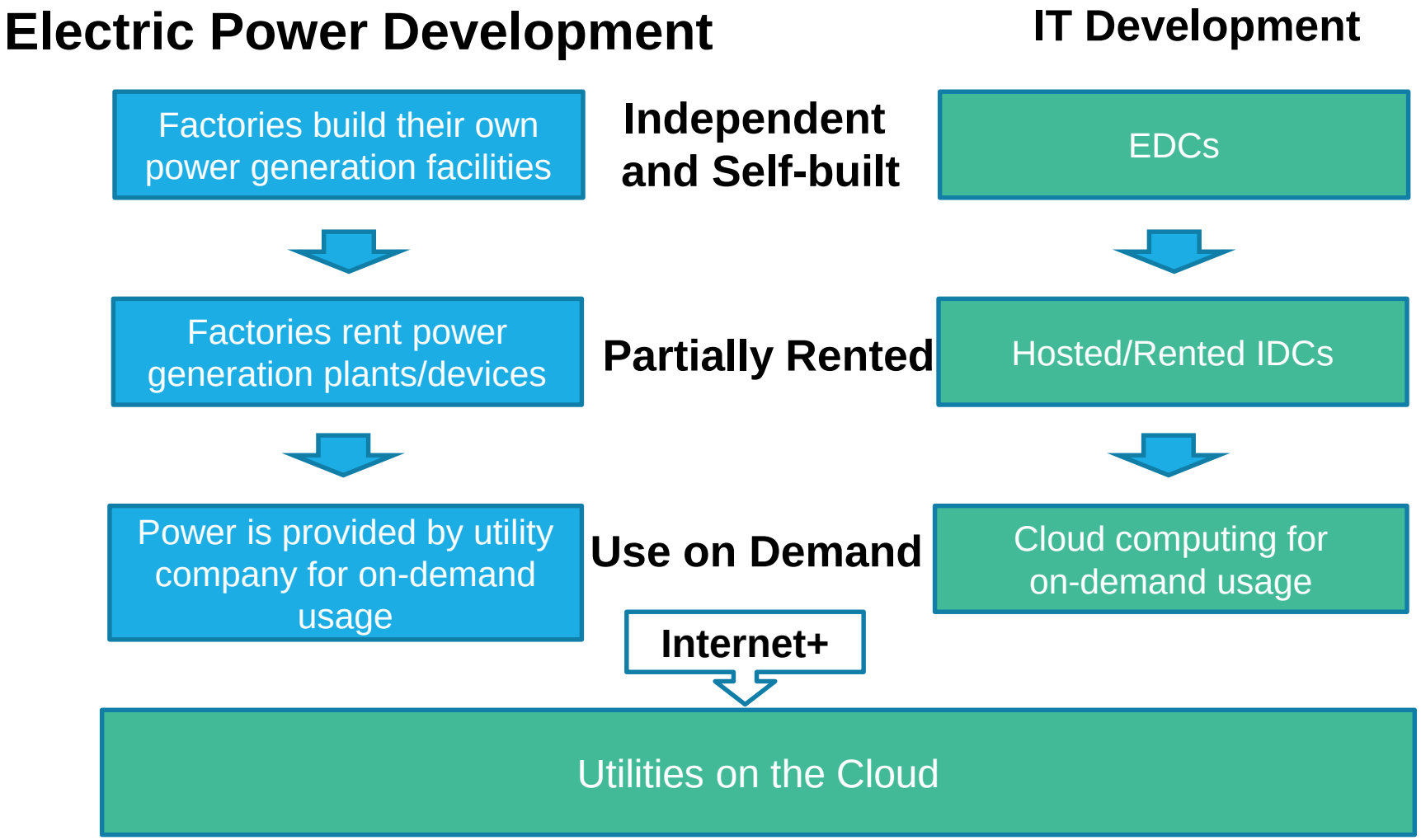
- **NIST’s definition:** Cloud computing is a model for enabling ubiquitous, convenient, and on-demand network access to a shared pool of configurable computing resources.



1.3 Features of Cloud Computing

Feature	Description
Massive scale	A public cloud often has hundreds of thousands or even millions of servers; a private cloud can have hundreds to thousands of servers.
High reliability	Multi-replica fault tolerance provides high reliability.
Isolation of tenants	Multiple tenants share the underlying hardware resources, but are logically isolated at the upper layers.
Elastic scaling	Dynamic scaling helps clients cope with the growth of applications and user base.
Service on demand	Cloud provides a large pool of resources which clients can purchase on demand.
Monitorable and measurable resources	Cloud platforms provide features for monitoring and measuring resources.
Low costs	Users only pay only for the resources they use, not the entire infrastructure.

1.3 Cloud Computing: IT as a Utility



1.4 Comparison

Item	EDC	Traditional IDC	Cloud computing
Rental Scope	None	L0, L1, and part of L2	**L0-L4**
Overall Costs	High	Moderate	**Low**
Launch Cycle	Long	Moderate	**Very Short**
OPS Management	Complicated	Moderate	**Simple**
Scalability	Difficult	Moderate	**Elastic scaling**
Independence and Controllability	High	Medium	**(Public cloud/ private cloud)**

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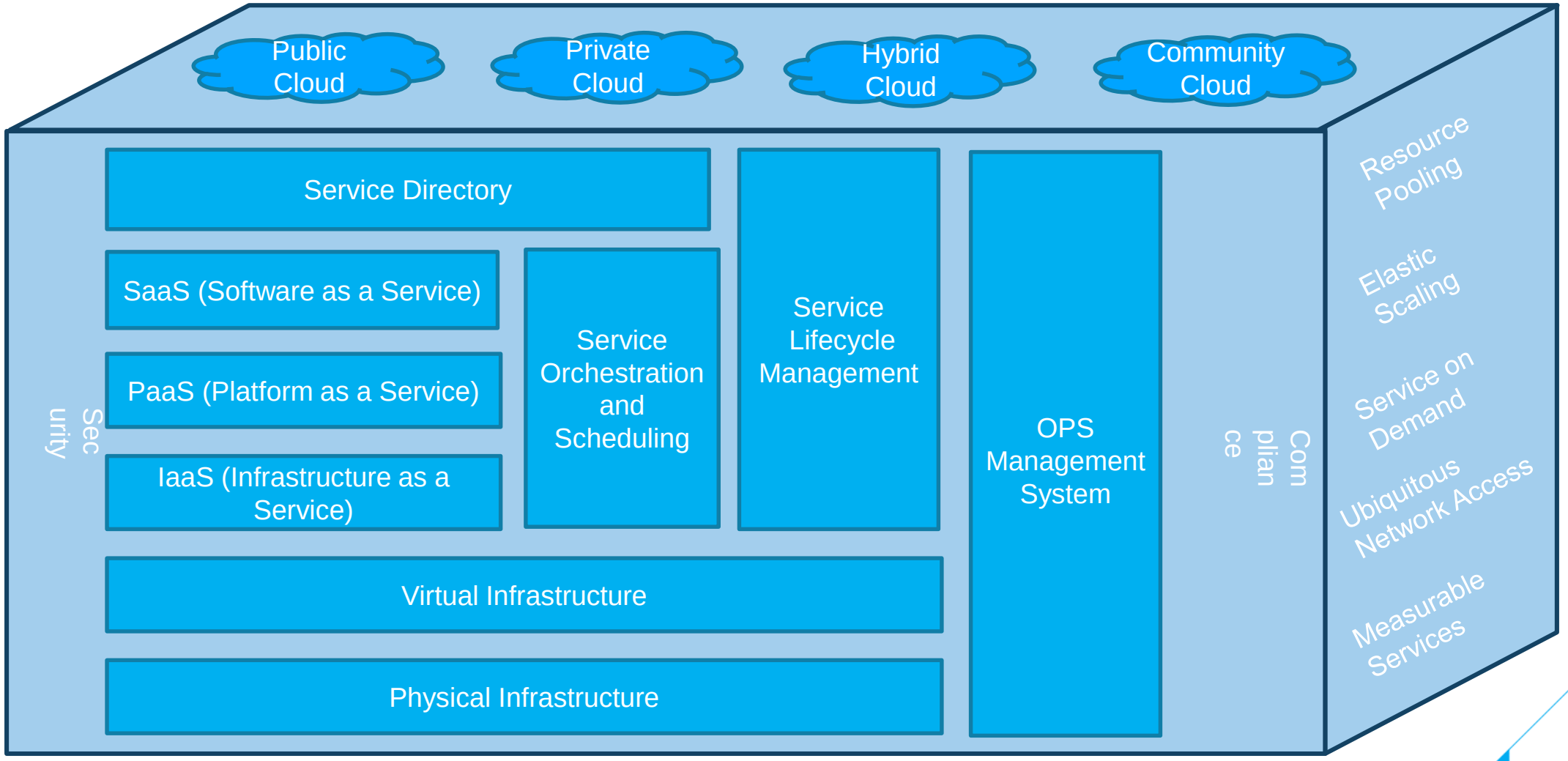
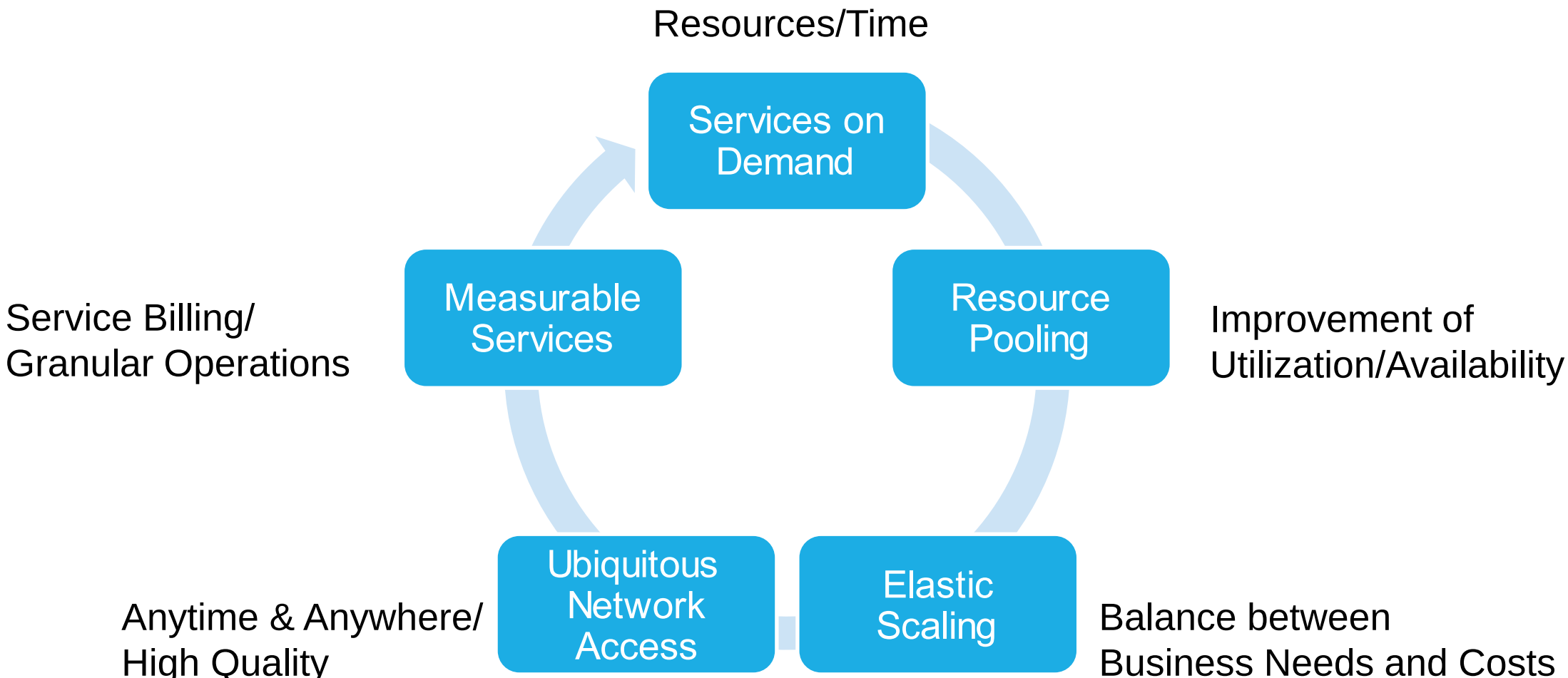
2.1 Cloud Computing Reference Model



2.2 Key Features of Cloud Computing



2.3 Cloud Computing Service Models

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SaaS

SaaS (Software as a Service) focuses on services and provides software and program services over the Internet.

PaaS

PaaS (Platform as a Service) focuses on platforms and provides server platforms or development environments in the form of services.

IaaS

IaaS (Infrastructure as a Service) focuses on the sharing of computing resources, allowing clients to get IT infrastructure resources from the resource pool over the Internet.

2.3 Cloud Computing Service Models

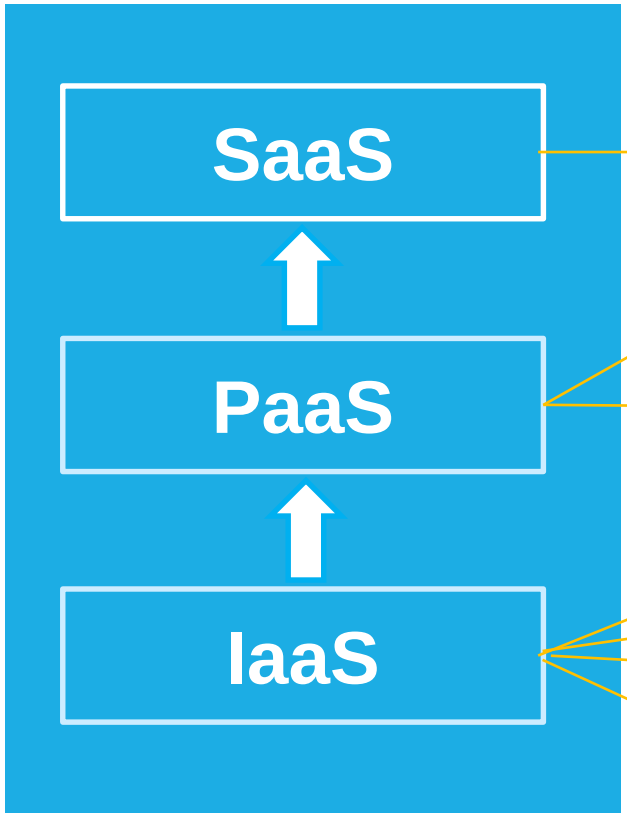
Basic Assessment

Do we need
a unified solution
for different
departments?

Do we need a shared operation platform such as databases, middleware, APIs, etc.?

Do we need to share hardware resources?

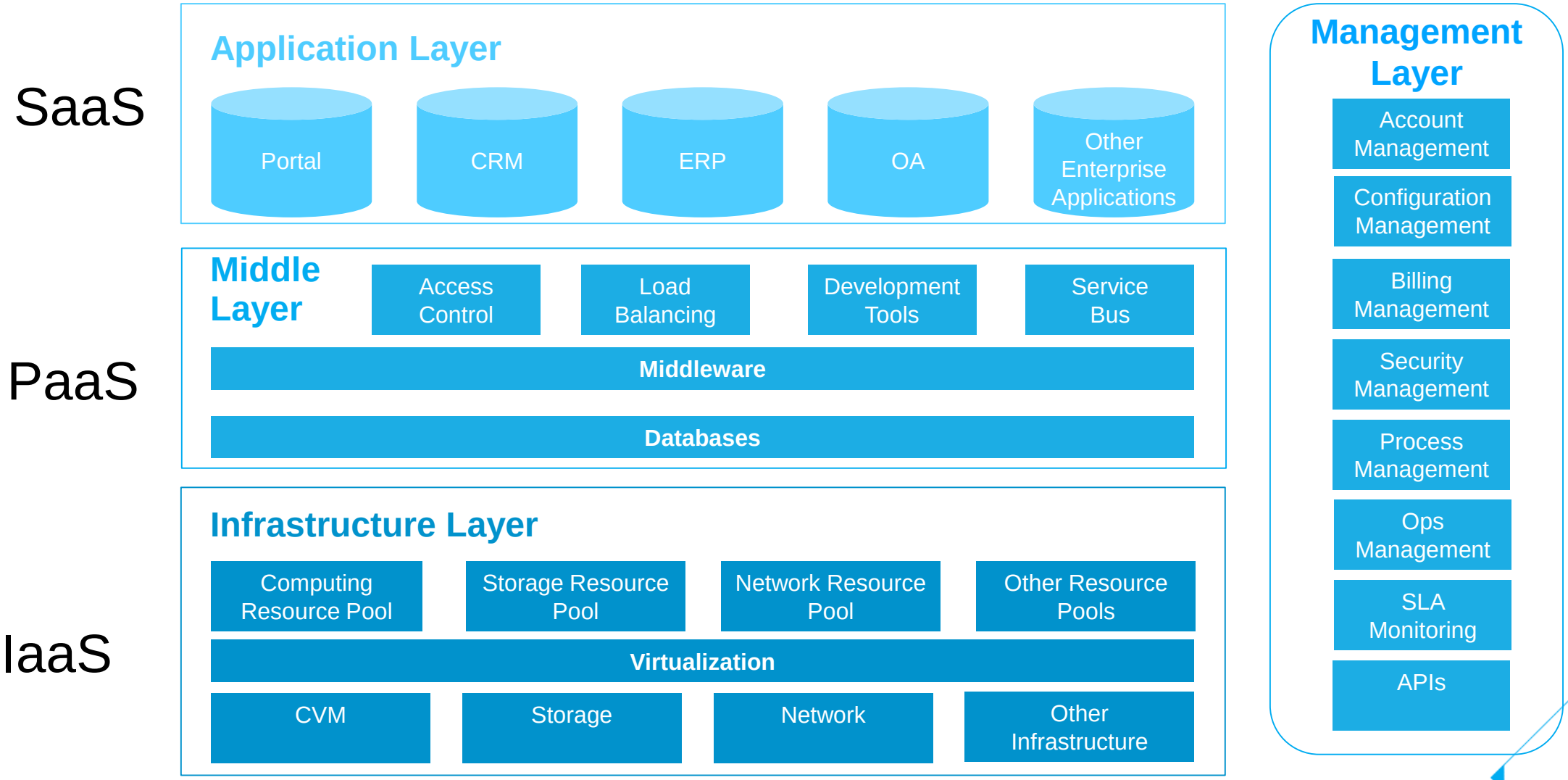
Cloud Service Layers



Advantages

- Unified services, procedures, models, and experience
- Elastic scaling for better scalability
- A unified platform for development, testing, and operation
- Centralized and automated resource management
- Rapid infrastructure supply
- Higher resource utilization and lower energy consumption
- Integration of hardware resources

2.3 Technical Architecture of Cloud Computing

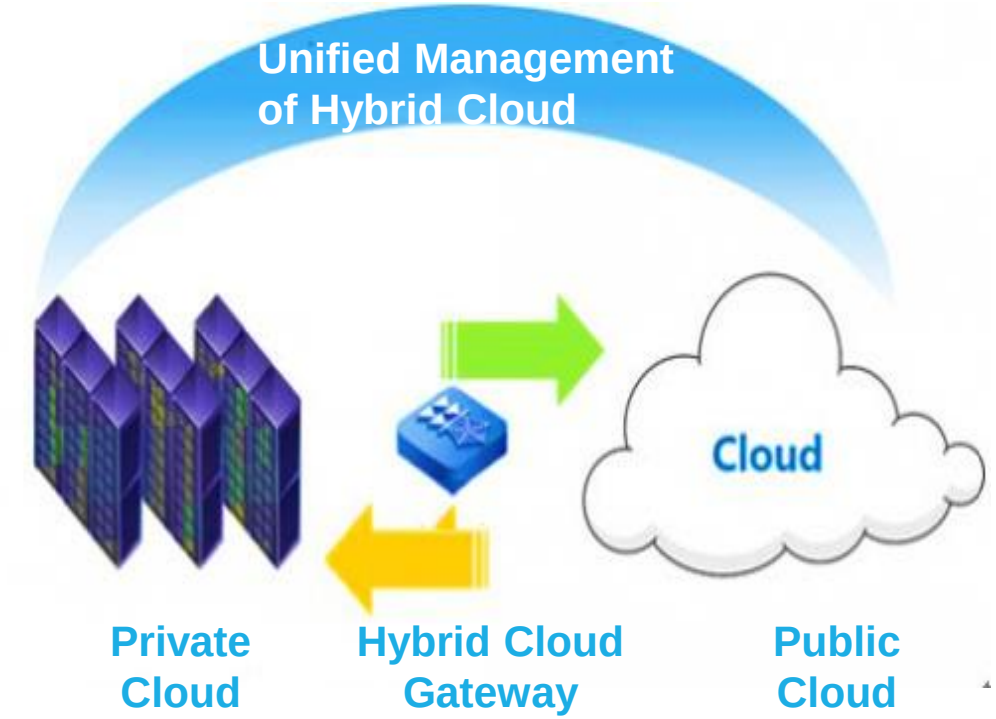


2.4 Public Cloud and Private Cloud

No.	Item	Public cloud	Private cloud
1	Cloud vendor and cloud tenants	Different organizations and multiple tenants	Same organization and single tenant
2	Underlying resources	Resources owned by service providers and used by clients	Resources owned and used by the client
3	Overall costs	Low	High
4	Ops complexity	Simple	Complex
5	Independence and controllability	Low	High

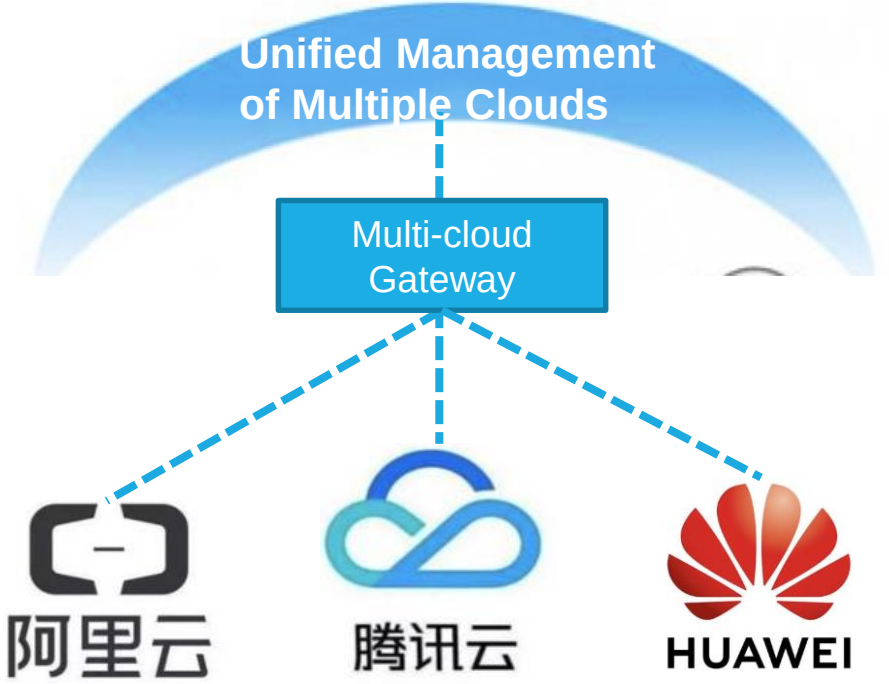
2.4 Hybrid Cloud

Type 1: Public Cloud + Private Cloud



- Critical applications and data are deployed on the private cloud (which is independent and controllable).
- Non-critical applications are deployed on the public cloud (which provides cost optimization and scalability).

Type 2: Multi-cloud



- Clients are not locked into a single vendor, improving service quality and bargaining power.
- Load balancing and disaster backup and recovery can be carried out across multiple clouds.

2.4 Community Cloud

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Business difficulty:

- Public clouds are not suitable for the specific needs of certain industries, due to a lack of business knowledge, insufficient technological reserves, and high customization costs.

Solutions:

- **Community cloud:** a public cloud that is highly optimized for specific industries. You can think of it as an Internet of industries.
- **Type I:** Public cloud vendors work with industry partners to develop industry-specific solutions, such as Tencent Cloud Smart Retail.
- **Type II:** Leading industry vendors integrate IT capabilities and sell them to others, such as MBCloud.

Tencent Cloud industry solutions

Gaming
E-commerce
Finance
Financial risk control
Health
Travel
Smart tourist attractions NEW
Government
Enterprise
O2O
Smart logistics
Rendering
Biology and genomics
Smart retail
Intelligent transportation
Intelligent manufacturing

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3.5 Application Virtualization

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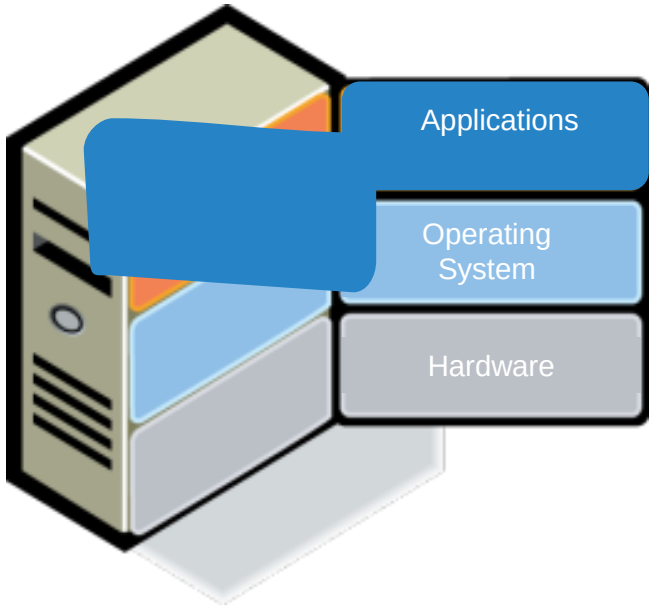
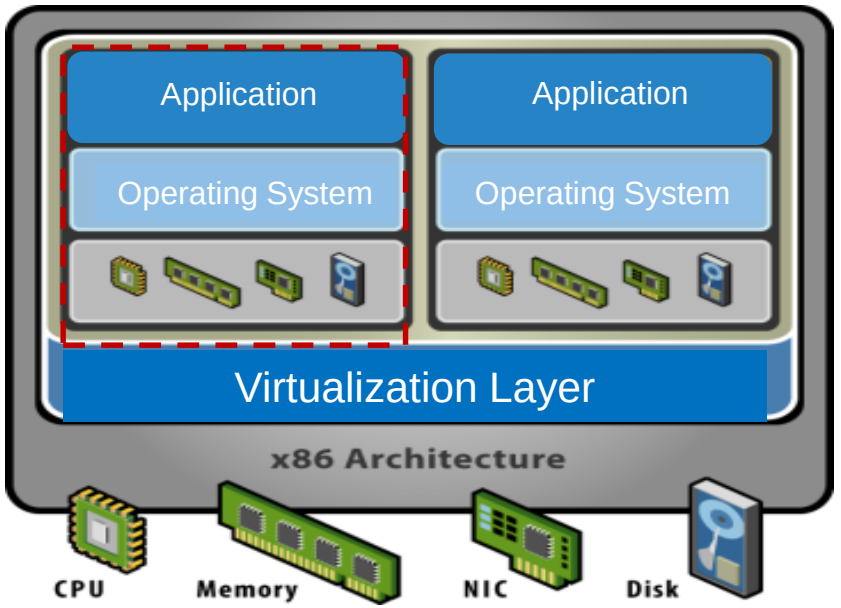
3.1 Virtualization

Before Virtualization



- Each machine runs a single operating system.
- Software is strongly coupled with hardware resources.
- Low resource utilization, poor scalability, and low fault tolerance.

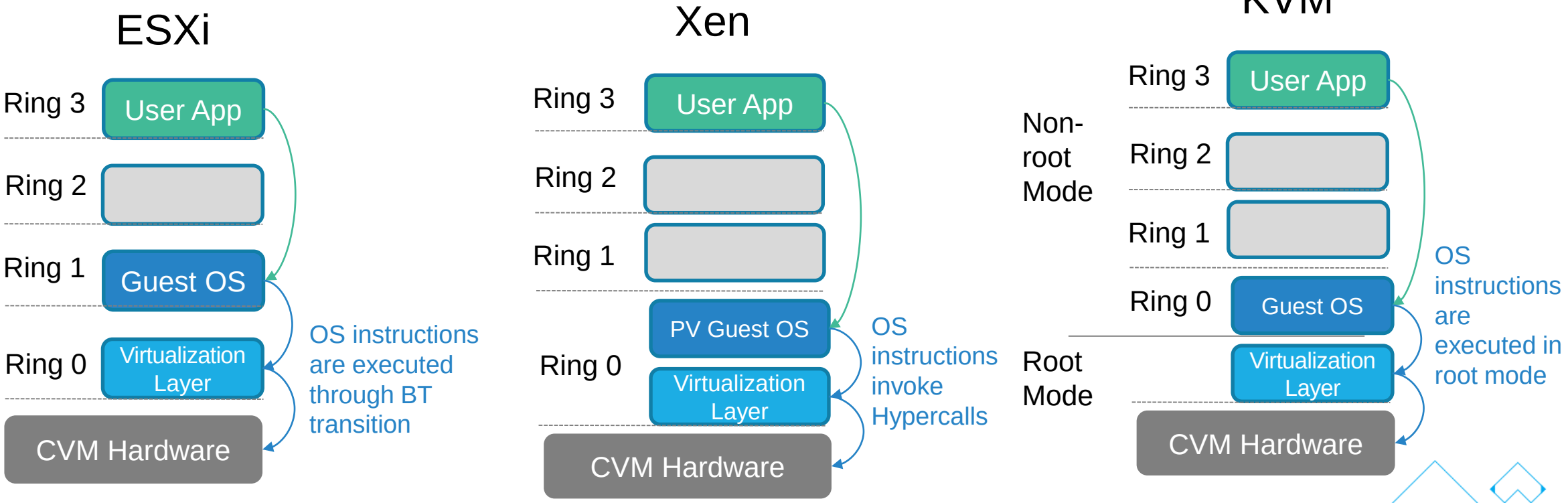
After Virtualization



- A bare-metal architecture, where the virtualization layer runs directly on the hardware.
- The virtual CPU and memory resource pools are shared among multiple VMs.
- Decoupling of hardware from software enables fault recovery and elastic scaling.

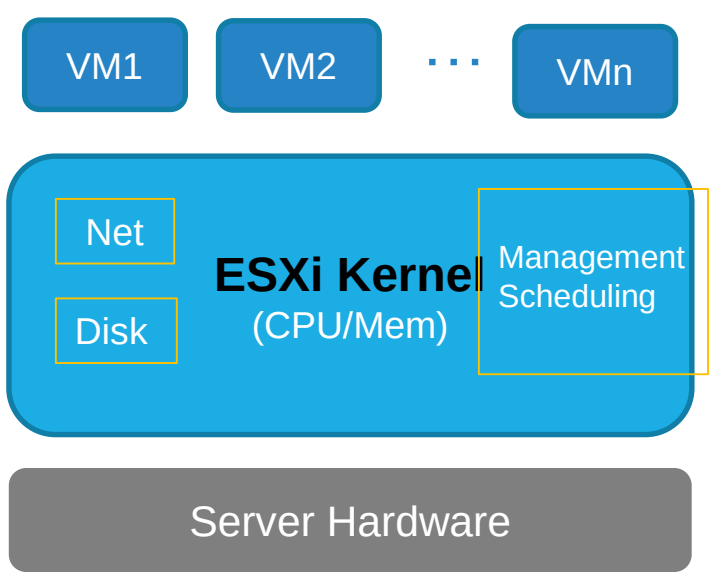
3.1 Types of Virtualization

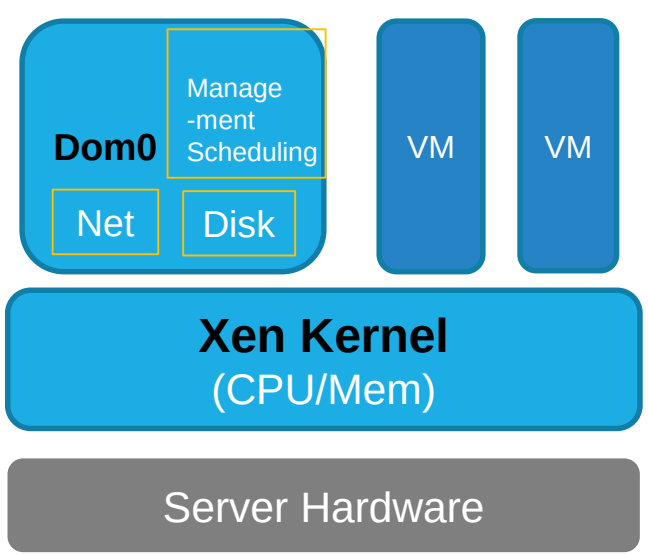
- **Full virtualization**: The guest OS runs directly on the virtualization layer, and no modification is needed, such as ESXi.
- **Paravirtualization**: The guest OS needs modification and additional drivers to function. For example, a Linux VM in Xen requires the installation of the PV Driver, while a Windows VM is fully virtualized and requires no modification.

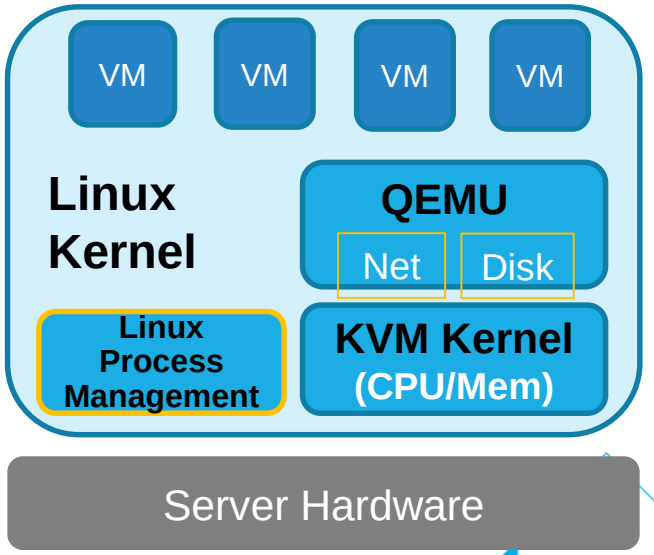


3.1 Comparison of Virtualization Types

Item	ESXi	Xen	KVM
Type of virtualization	Full virtualization	Full/Paravirtualization	Full virtualization
CPU and memory virtualization	ESXi kernel	Xen kernel	KVM kernel
Disk/Network I/O virtualization	Virtualization kernel	Dom0	QEMU
Scheduling and management of virtualization	Virtualization kernel	Dom0	Linux process management

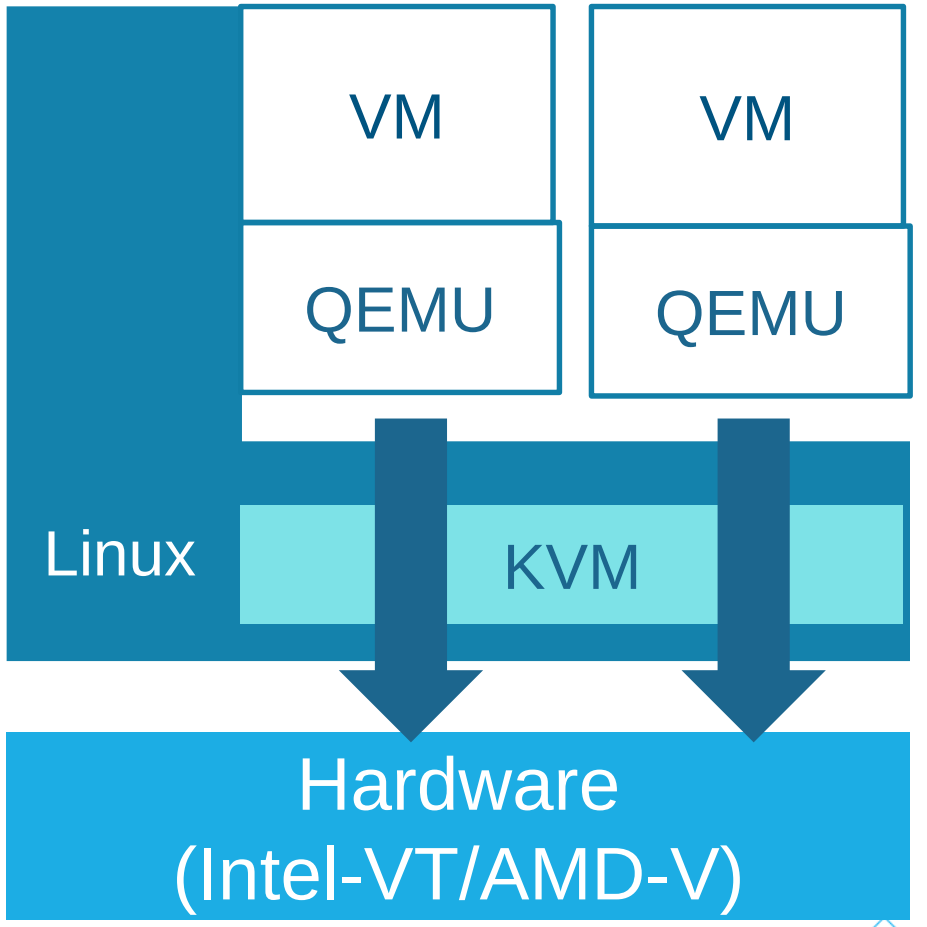




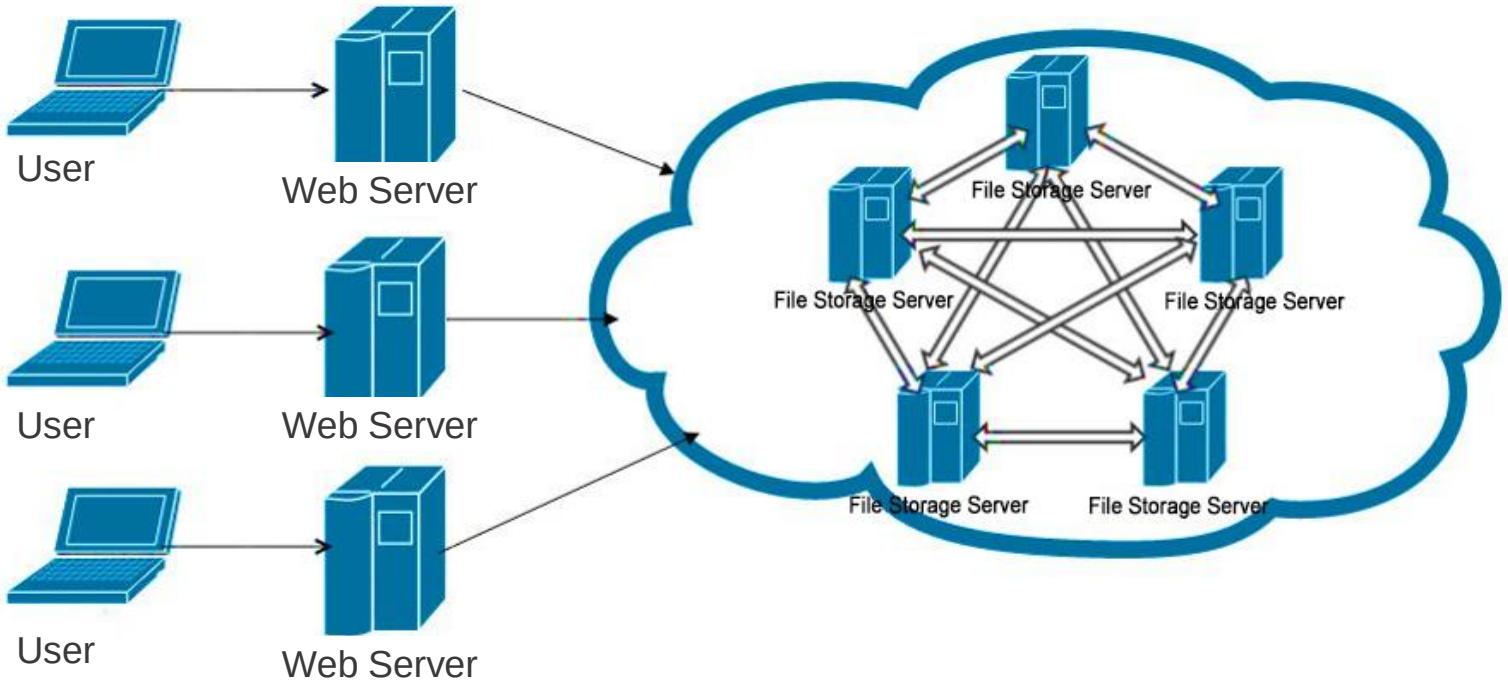


3.1 Virtualization - KVM

- KVM was released as a Linux kernel module since Linux version 2.6.20. VM is a system process which is scheduled and managed through Linux processes.
- The KVM kernel is responsible for CPU and memory virtualization, and QEMU is responsible for I/O virtualization (device emulation). Hardware virtualization powered by Intel-VT and AMD-V is required.
- Due to the advantages of KVM, such as superior performance, high scalability, and easy management, many vendors are gradually migrating to KVM.



3.2 Distributed Data Storage Technology



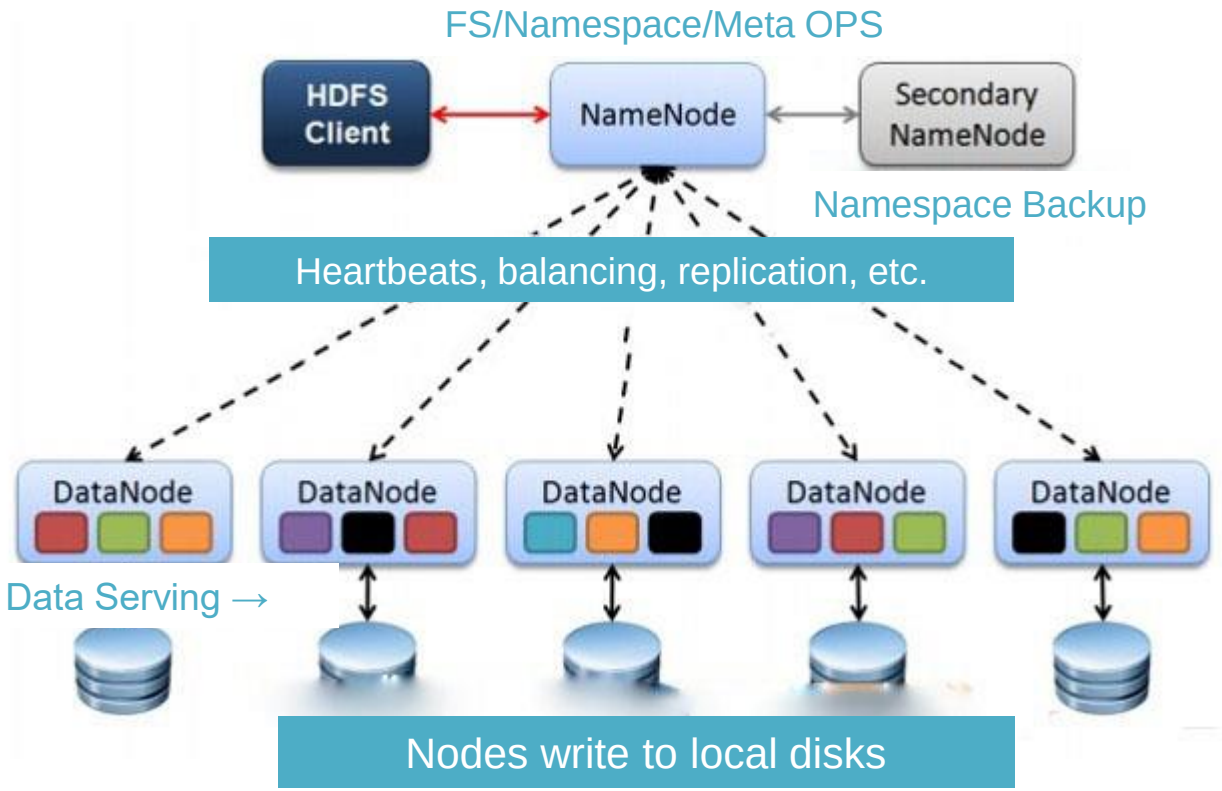
- Runs on **multiple** nodes with automatic integration.
- Integrates all storage resources in the cluster, virtualizes them, and provides file access services.
- Provides better scalability and larger capacity, making it more suitable for the performance requirements of massive data.

3.2 Distributed Data Storage Technology - HDFS

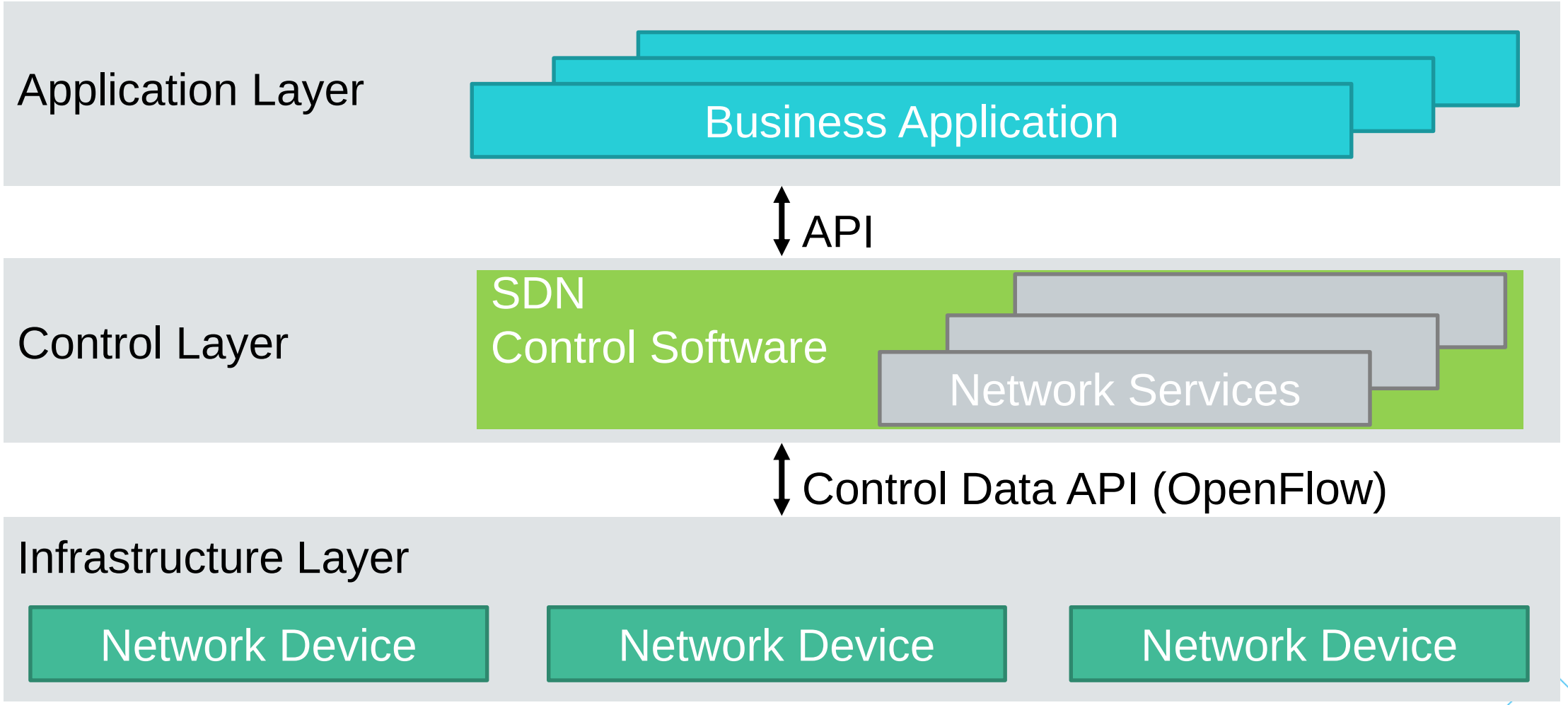
HDFS (Hadoop Distributed File System)

Features

Multi-replica fault tolerance	Runs on low-cost hardware	Suitable for Big Data Processing

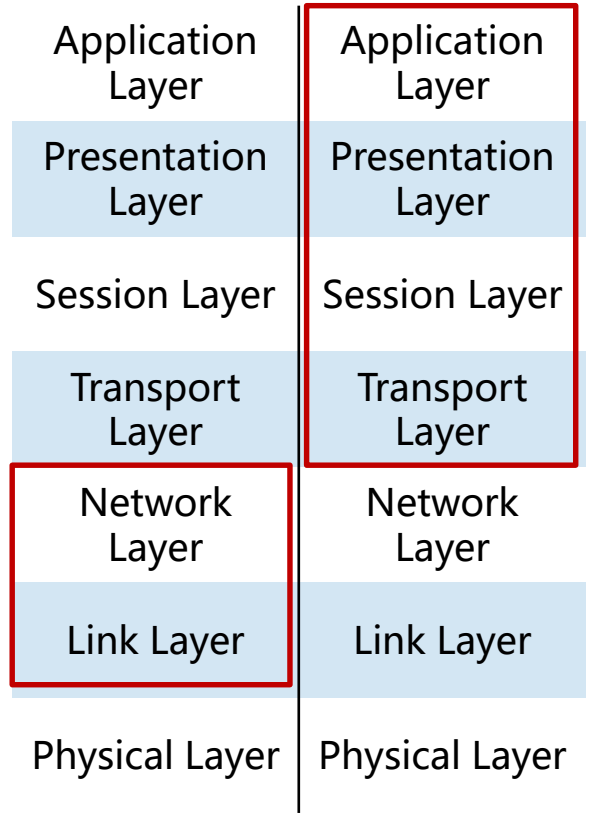


3.3 Network Virtualization - SDN



3.3 SDN vs. NFV

Item	Software-defined Network (SDN)	Network Function Virtualization (NFV)
Features	• Separation of control plane from data plane • Universal routers and switches • Programmable control plane	• Decoupling of network functions from hardware • Replacement of proprietary hardware with commercial hardware • Programmable data plane
Use cases	• Campus networks and IDC networks	• ISP networks
Optimizations	• Processes data on OSI layers 2-3 and optimizes switches, routers, and wireless capabilities	• Processes data on OSI layers 4-7 and optimizes network functions, load balancing, firewall, and WAN
Benefits	• Cost optimization, fast launch, simplified Ops, and elastic scaling	



OSI Model

3.4 OpenStack Cloud Management Platform

- OpenStack is an open-source cloud computing management platform, which provides the following service components:
- **Pros:**
  - Open source
  - Compatible with many cloud platforms
  - Standardized
- **Cons:**
  - Complex deployment, Ops, and upgrade
  - Poor performance and scalability
  - Inadequate disaster recovery capabilities

Service Name	Function
Nova	Computing service
Neutron	Network service
Keystone	Verification and authorization service
Glance	Image service
Swift	Object storage service
Cinder	Block storage service
Horizon	Graphical management interface
Ceilometer	Monitoring and measurement service
Heat	Orchestration and scheduling

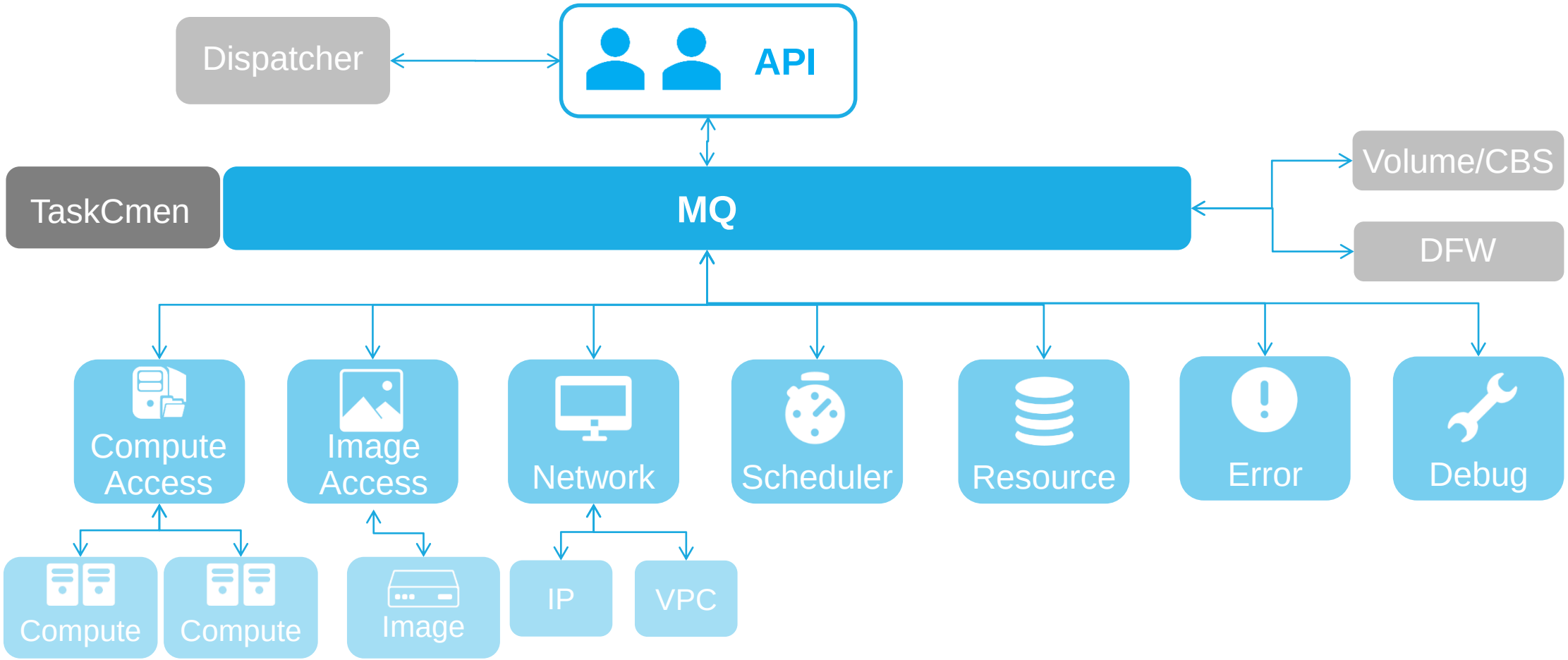
3.4 Tencent Cloud Management Platform - VStation

- VStation is a cloud computing management platform developed by Tencent.

Design Principles

Parallel extension, simple and efficient, and asynchronous
Fail-fast, stateless, and highly available
Shared channels (such as Ethernet)
Transaction processing (such as SQL)
Logical separation (such as CGI)
Easy to trace (such as Git)

3.4 Tencent Cloud VStation Architecture

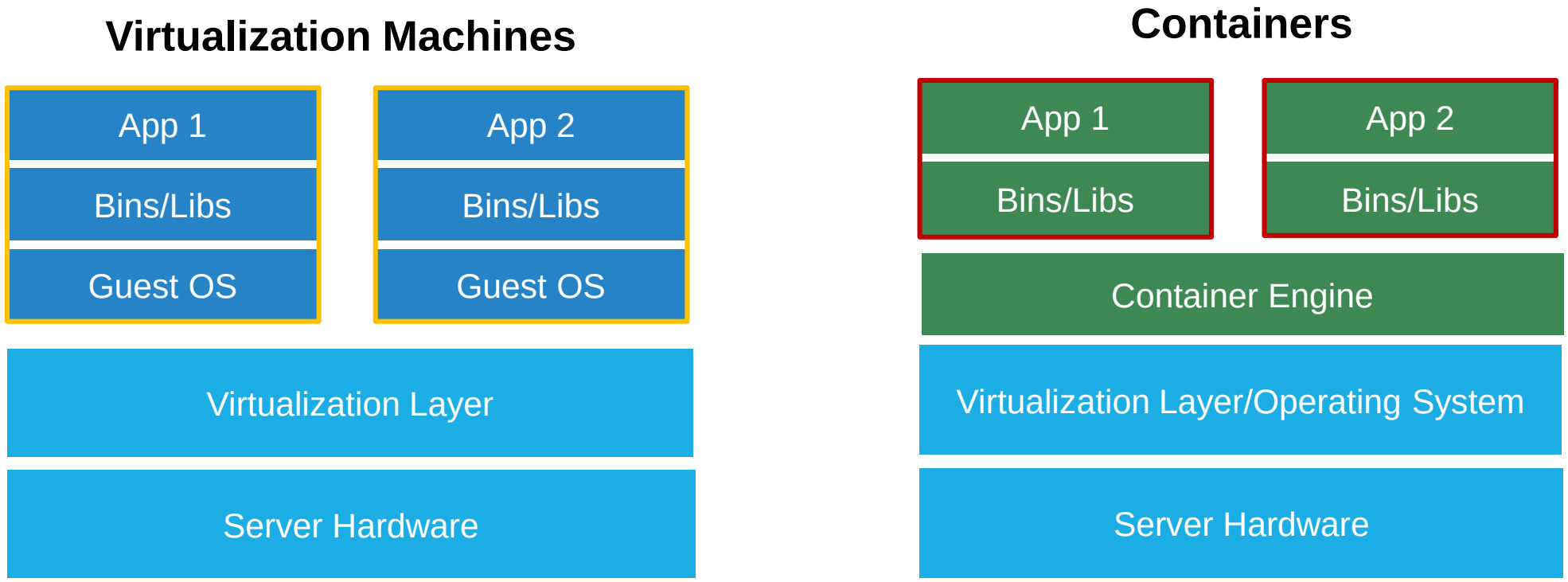


3.4 OpenStack vs. VStation

OpenStack		VStation
Tens of millions of lines	Code Length	Hundreds of thousands of lines
Thousands of servers	Cluster scale	Hundreds of thousands of servers
Requires other open source components	Disaster recovery	Disaster recovery can be deployed on any module across data centers
Separate development is required	Ops	Monitoring and alarming and visualized Ops
Hundreds of people	HR investment	Dozens of people
Normally only supports creating fewer than 100 servers simultaneously	Performance	Supports creating tens of thousands of virtual machines in minutes

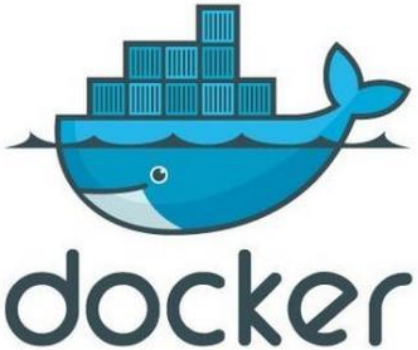
3.5 Application Virtualization: Containers

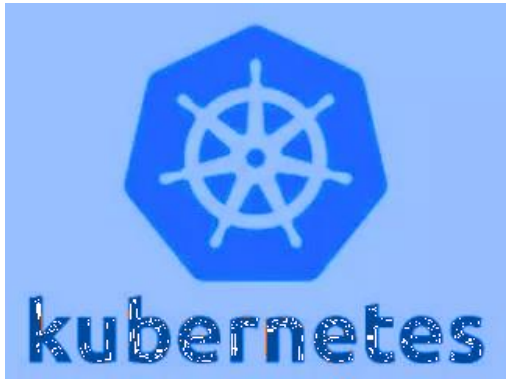
- A **Container** is a lightweight virtualization technology that packages and encapsulates an application and the resources and configurations it depends on through process isolation. A container provides an independent and portable runtime environment.



3.5 Application Virtualization: Containers

- **Docker:**
  - The most popular container technology, known for its standardization and portability. Its motto is: **Build, Ship and Run Any App, Anywhere**
- **Container management:**
  - Kubernetes (K8S) is an open source container orchestration and scheduling technology.
- **Container benefits:**
  - Extremely lightweight: lightweight packaging, fewer resources, and good performance
  - Deployment in seconds: containers deployed in milliseconds or seconds
  - Portable: standardized, build once and deploy anywhere
  - Elastic scaling: rapid scaling using an orchestration tool

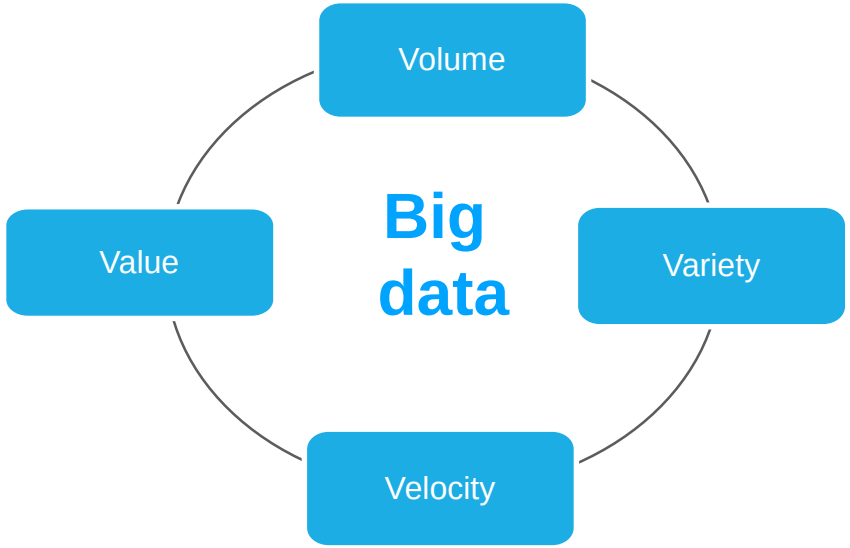




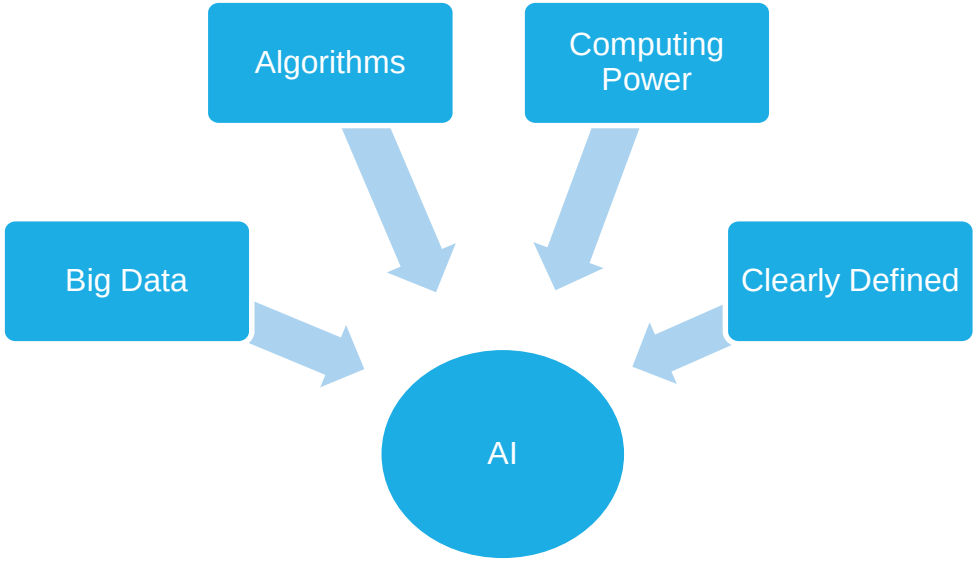
3.6 Big Data & Artificial Intelligence

- **In the future, the Internet will use AI to process big data in the cloud.** -- Pony Ma
- **Applications:** Big data is used in precision marketing, decision-making support, and risk control. AI is used in image, voice, and self-driving technologies.

The Four V's of Big Data



The Four Elements of AI



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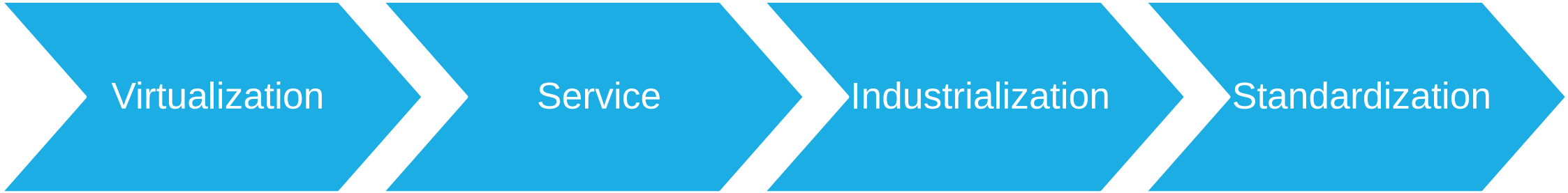
4.1 Development History of Cloud Computing



1960--2005	2006--2018	2018--	Future
• Full/para-/hardware-assisted virtualization • Software and hardware decoupling/Resource pooling • Higher local efficiency/reliability	• Technical capabilities -> Service output • IaaS, PaaS, and SaaS • Cloud services extend the capabilities of applications	• Industrial Internet • Industry ecosystems and solutions • Migration to Cloud/Cloud transformation	• Seamless migration among public clouds, private clouds, and multi-cloud architectures • Convenience: Like any other utility • Cloud-native applications

4.2 Impact of Cloud Computing on Industries

Software Vendors

- Changes in demand
- Product transformation

Server Vendors

- Software delivery methods
- Sales and release methods
- Technological changes

Cloud Terminal Vendors

- Increased demand
- Terminal-type evolution

Cloud Providers

- Larger scale
- Lower costs
- Stable business

4.2 Impact of Cloud Computing on Industries

- **What is Industrial Internet?**

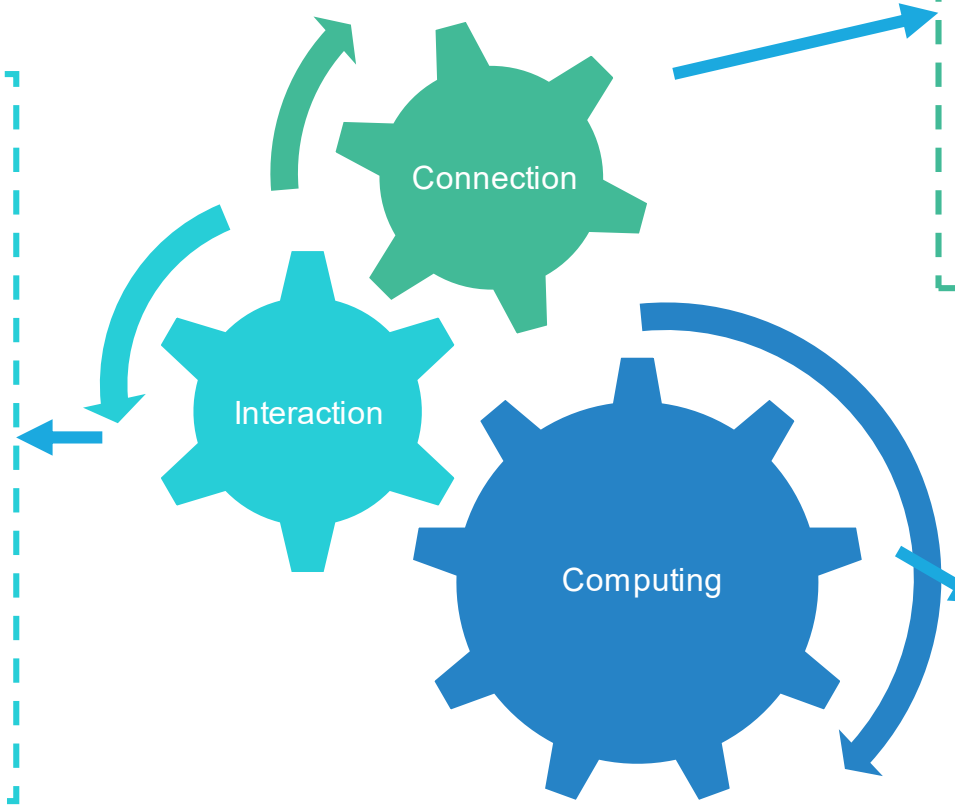
Internet	Internet+	Industrial Internet
		
Connects People Helps people better communicate and build social connections by improving the efficiency of information exchange.	**Connects Services** Helps services better reach users by providing efficient and convenient service distribution methods.	**Connects Industries** Helps enterprises in different industries to improve services and work together to meet users' demand.
C2C/B2C	B2B2C	C2B2B2C

4.2 Impact of Cloud Computing on Industries

- **Information technology facilitates the smart transformation of industries.**

Networking - the digital world connects with the real world

- Internet/Mobile Internet/IoT
- 5G
- Blockchain
- …



Convergence - the digital world interacts with the real world

- Digital twins
- Virtual reality/Augmented reality/Mixed reality
- Robots
- 3D/4D printing
- …

Digitization and intelligentization - data conversion, storage, and processing in the two worlds

- AI
- Big data
- Cloud computing
- ...

4.2 Impact of Cloud Computing on Industries

- **Five characteristics of the Industrial Internet framework**

	Conventional industries		Industrial Internet
Market	Separated	▶	**Integration:** Precise matching of supply and demand and cross-industry collaboration
Products	Physical	▶	**Digital:** Physical products are embedded with digital features; products are provided as a software or service
Operation	Manpower -driven	▶	**Man-machine collaboration:** Man-machine collaborative operations based on data and algorithms
Organization	Hierarchical	▶	**Elasticity:** Networking, flat organizational structure, and self-adaptation
System	Vertical	▶	**Interconnection:** Infrastructure sharing + Integrated technology applications + Open platform

4.3 Impact of Cloud Computing on Organizations: Clients

Cost Optimization

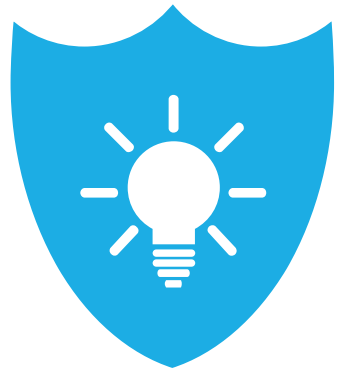
- Procurement & Ops costs
- Higher resource utilization
- Use services on demand and pay as you go

Business Flexibility

- Shorter launch cycle
- Elastic resource scaling
- Precision marketing and risk control

Granular Operations

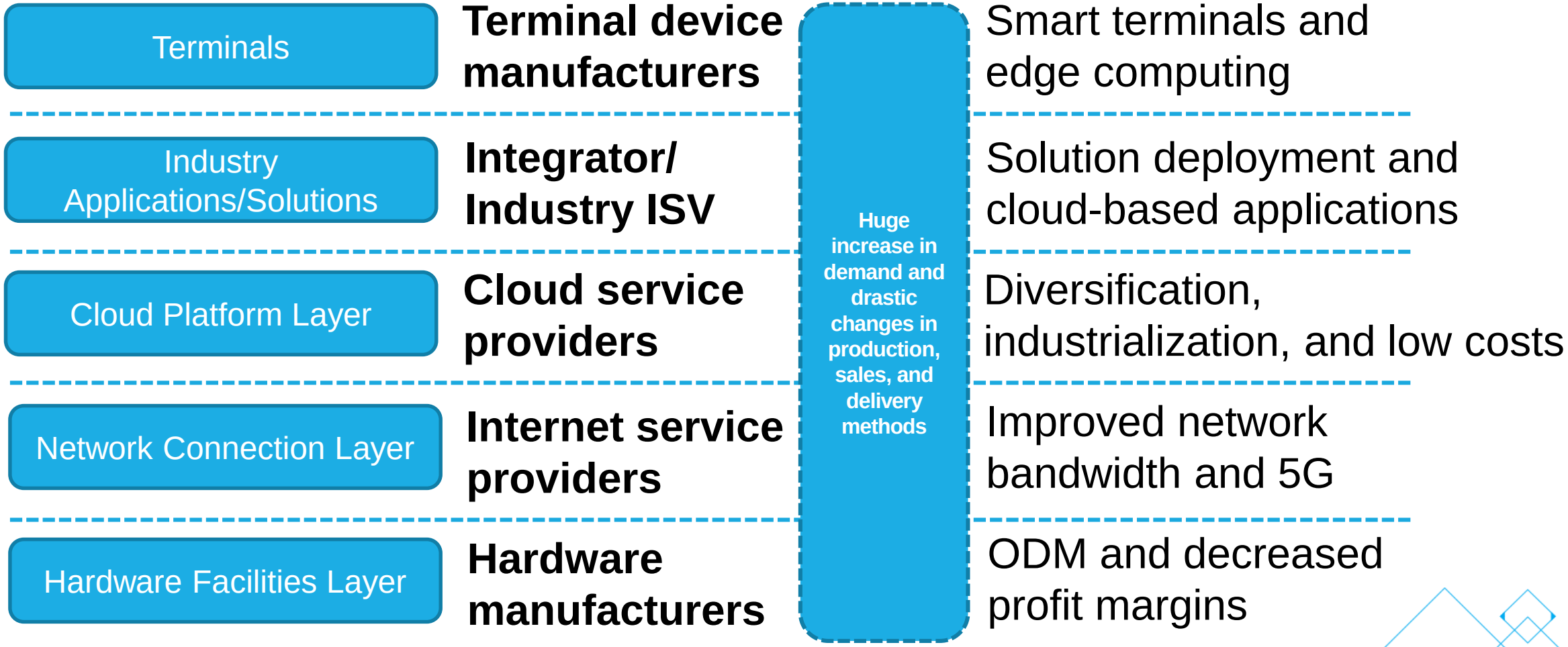
- Service metering and billing
- Cost optimization and control
- Support for data analysis



Organizational Optimization

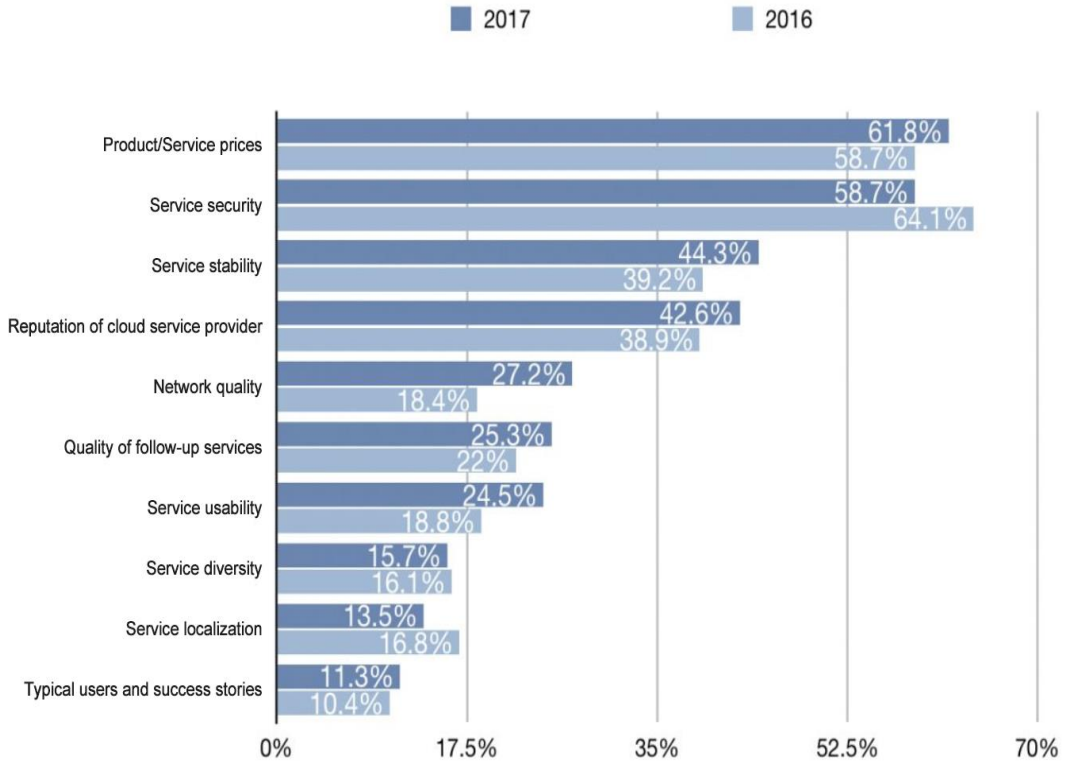
- Focus on core business
- Optimization of personnel and skills
- Enhancement of organizational culture

4.3 Impact of Cloud Computing on Organizations: Vendors



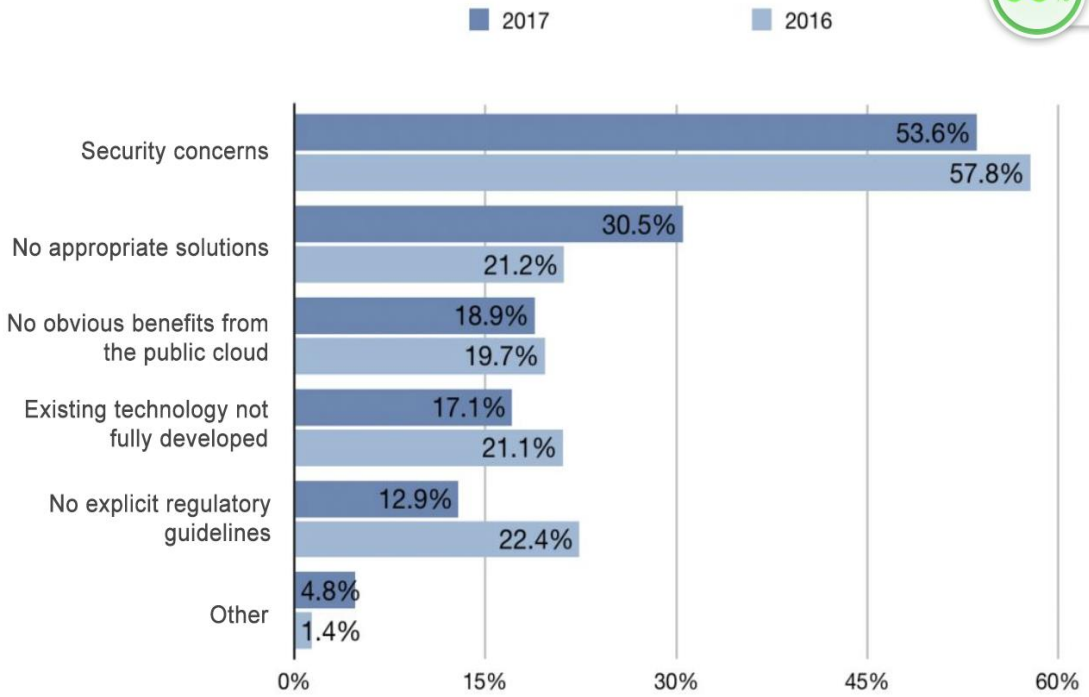
4.3 Demands and Challenges of Cloud Migration

Migration to the Cloud – Influencing Factors



Source: CAICT survey (3,900 valid samples)

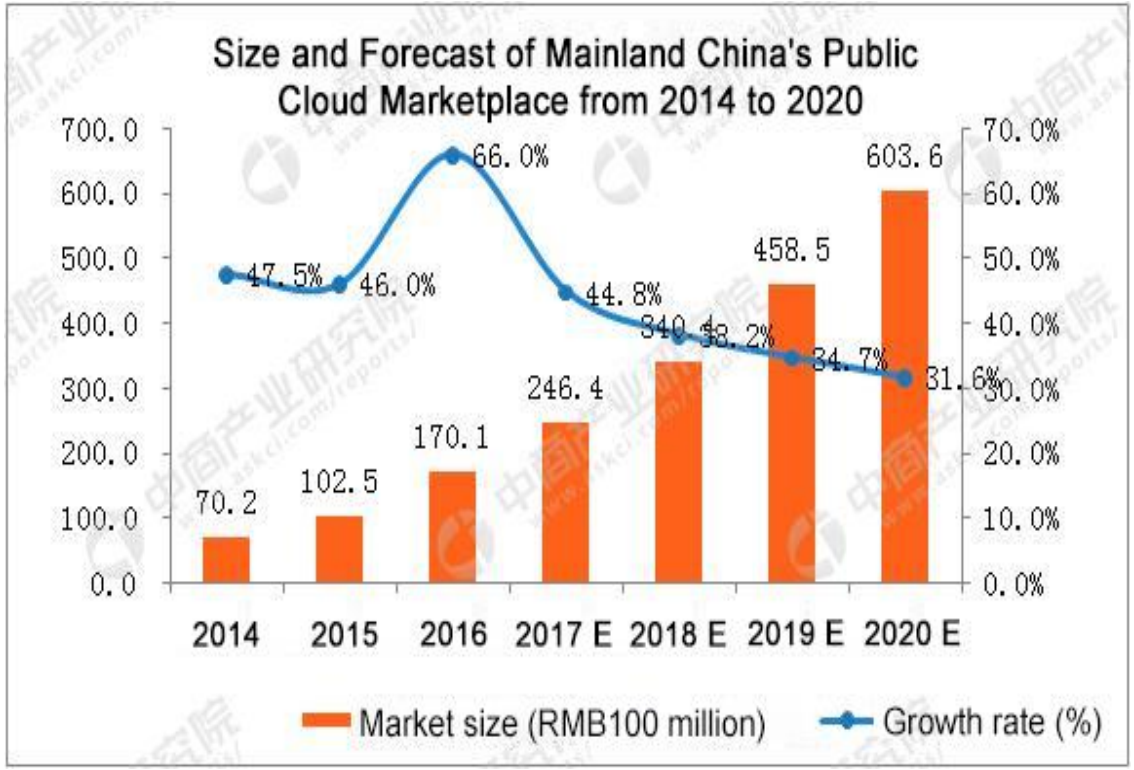
Migration to the Cloud – Concerns



Source: CAICT

4.4 Market Size in Mainland China

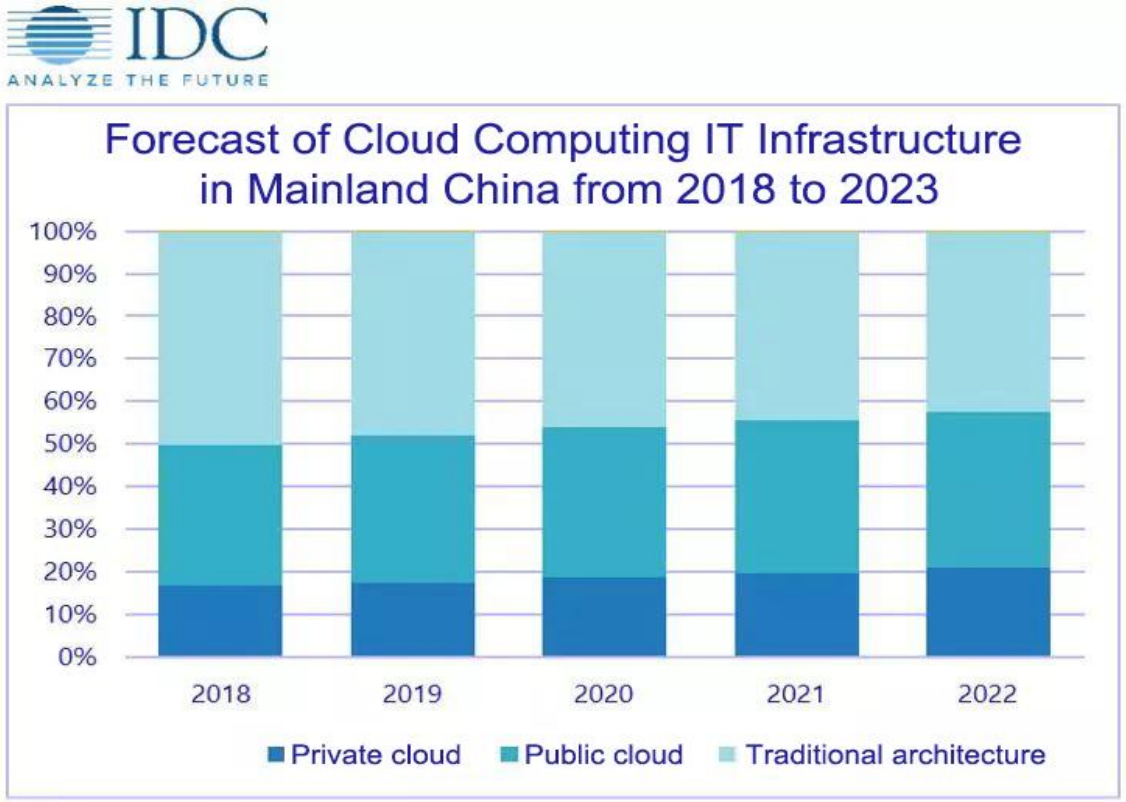
- **The size of mainland China's cloud computing market has exceeded 100 billion RMB and continues to grow rapidly.**



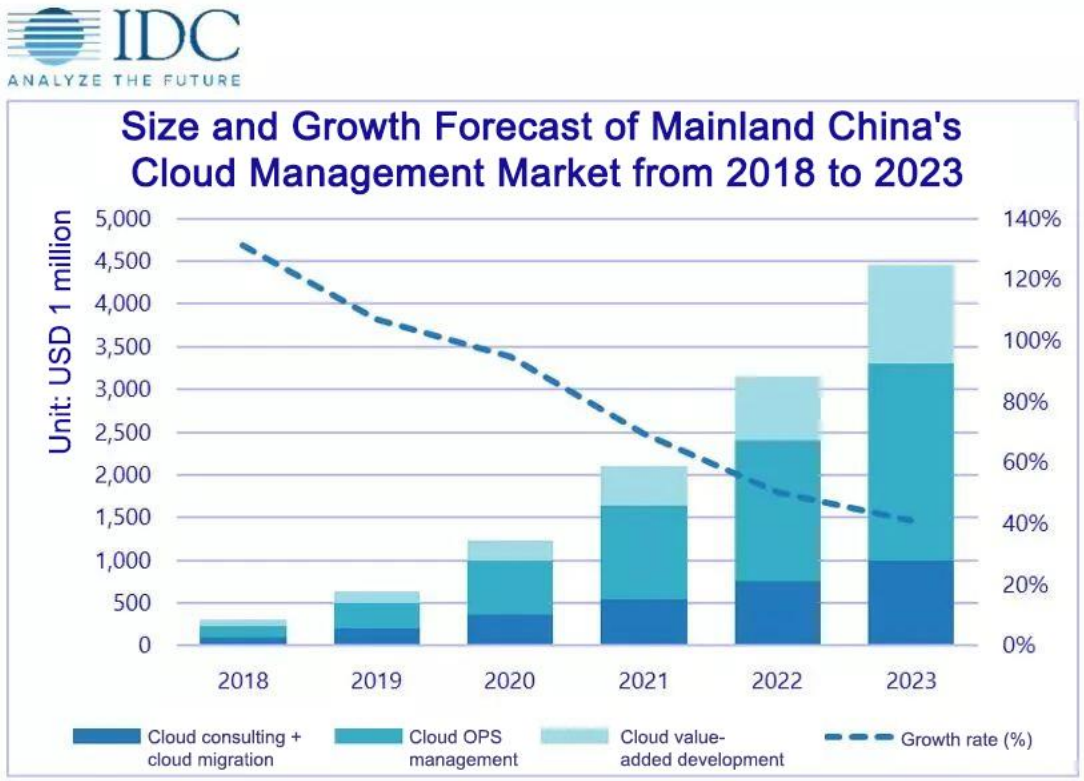
Sources: CAICT, ASKCI Industrial Research Institute

4.4 Cloud Market Share in Mainland China

- **The market share of public clouds and private clouds is gradually increasing, and the potential and demand for cloud migration and transformation services is huge.**



Source: IDC China, 2019



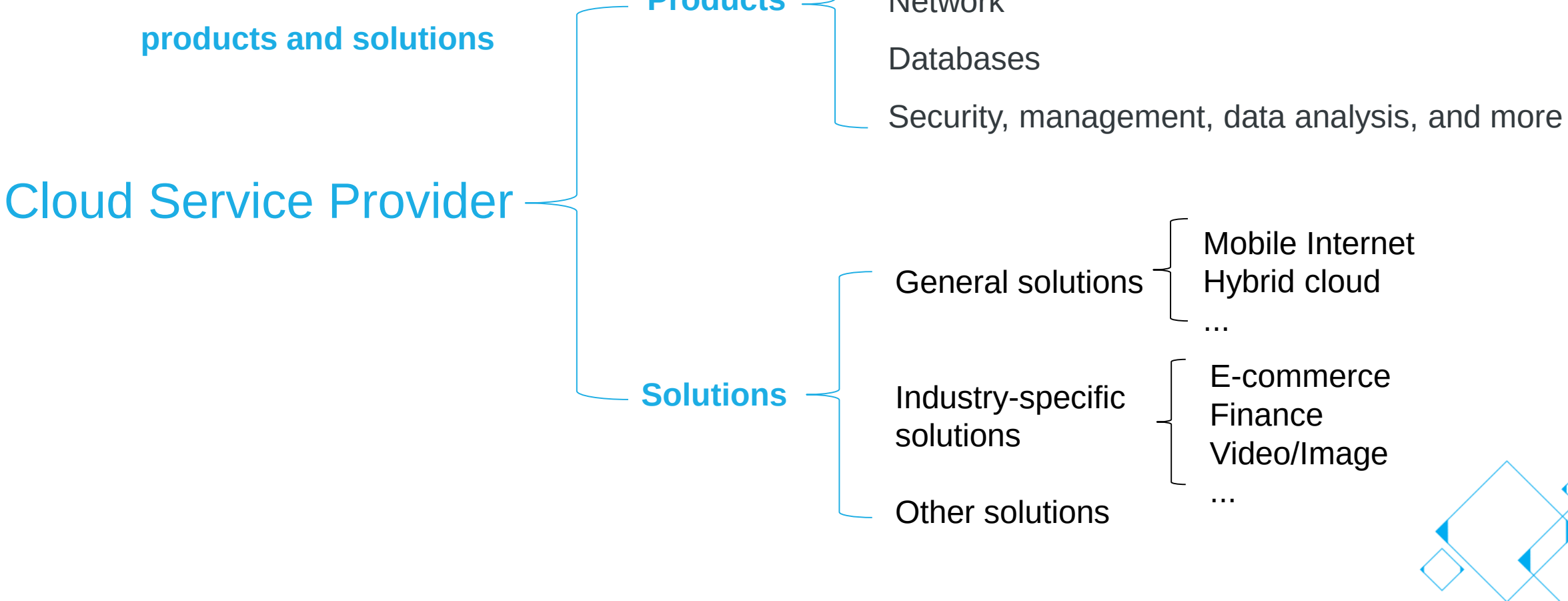
Source: IDC China, 2019

4.4 Mainstream Vendors in Mainland China

Vendor Type	Advantages	Disadvantages
Internet enterprise	Strong R&D capabilities, practical experience with large-scale systems, comprehensive product solutions, and scale advantages	Private cloud capabilities and service capabilities
Conventional IT enterprise	R&D capabilities, ISP service experience, private cloud and conventional IT, and service capabilities	Public cloud capabilities and product solutions
Telecom carrier	Abundant network bandwidth and IDC resources	Technical R&D and operation capabilities
International enterprise	First-mover advantage (in technology, market share, and ecosystems)	Market regulation and compliance and capabilities to provide service locally
Other vendors	Focus on specific fields or markets, alliance clouds	Technical R&D, highly specialized, and high costs

4.4 Features and Strengths of Cloud Vendors

- Different cloud service providers offer different services.
- Vendors generally provide both **products and solutions**



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CONTENTS

Chapter V Tencent Cloud

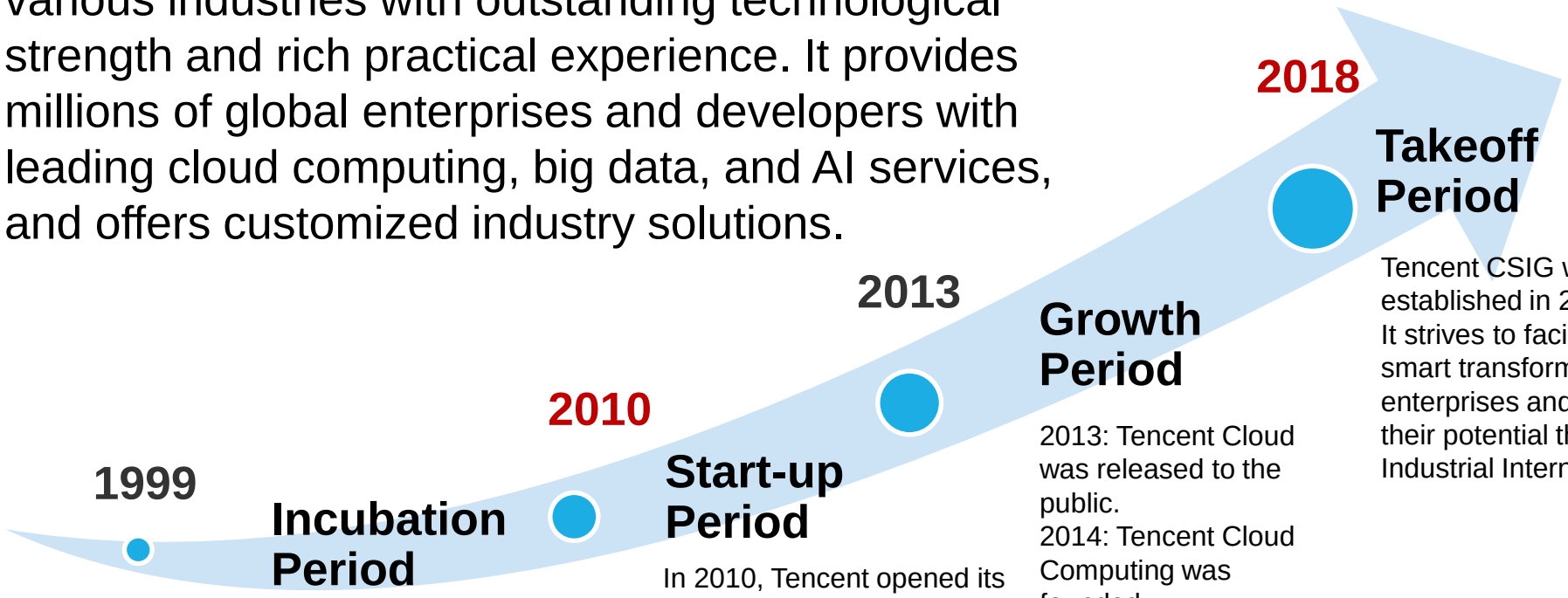
5.1 Development History of Tencent Cloud

5.2 Competitive Advantages of Tencent Cloud

5.3 Tencent Cloud Success Stories

5.1 Development History of Tencent Cloud

- Tencent Cloud is the cloud computing brand built by Tencent. We facilitates the digital transformation of various industries with outstanding technological strength and rich practical experience. It provides millions of global enterprises and developers with leading cloud computing, big data, and AI services, and offers customized industry solutions.



5.2 Competitive Advantages of Tencent Cloud

Diversified Services	Global Presence	Practical Experience	R&D Capabilities	Economies of Scale
• Hundreds of cloud products • 190+ solutions • Exploration of new technologies and solutions	• 25 regions around the world • 53 availability zones • 1300+ cache nodes • 80 Tbps of overall bandwidth	Development and Ops experience with massive apps: QQ, WeChat, and WeChat Pay	• Leading contributor to KVM • Leading cloud host performance • Leading database performance	•Low purchase cost •Low Ops costs •Cost-effective services

5.2.1 Strong R&D

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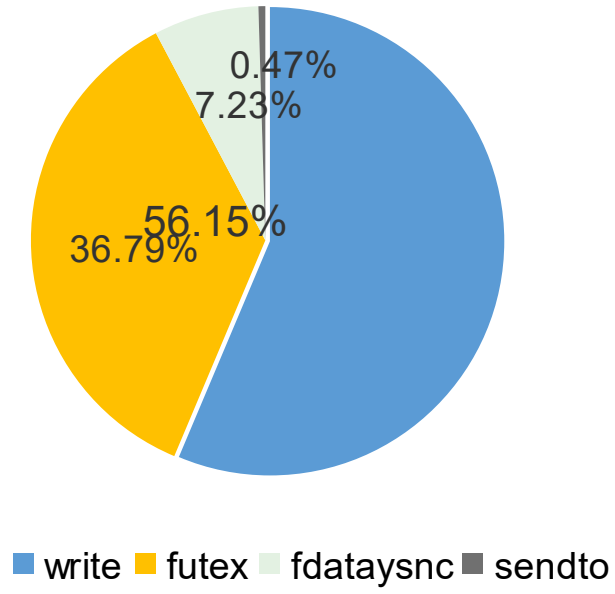
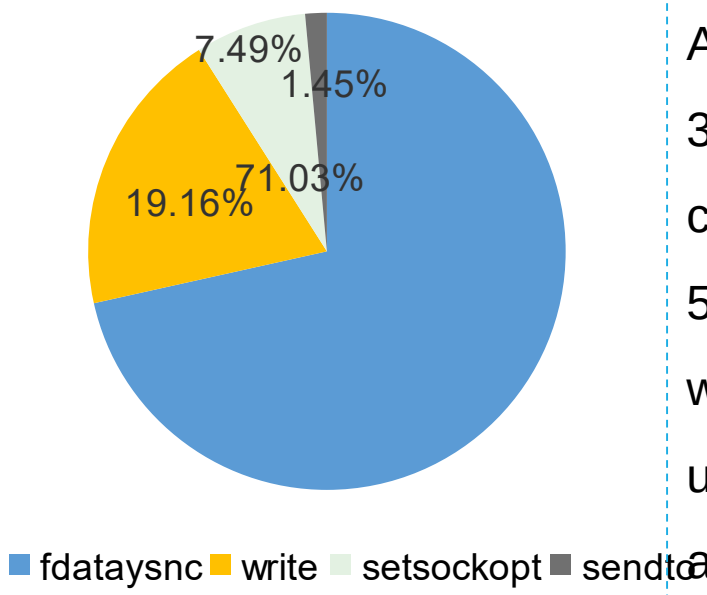
MySQL 5.7 I/O Thread Performance Sampling



PK

Logbus I/O Performance Sampling

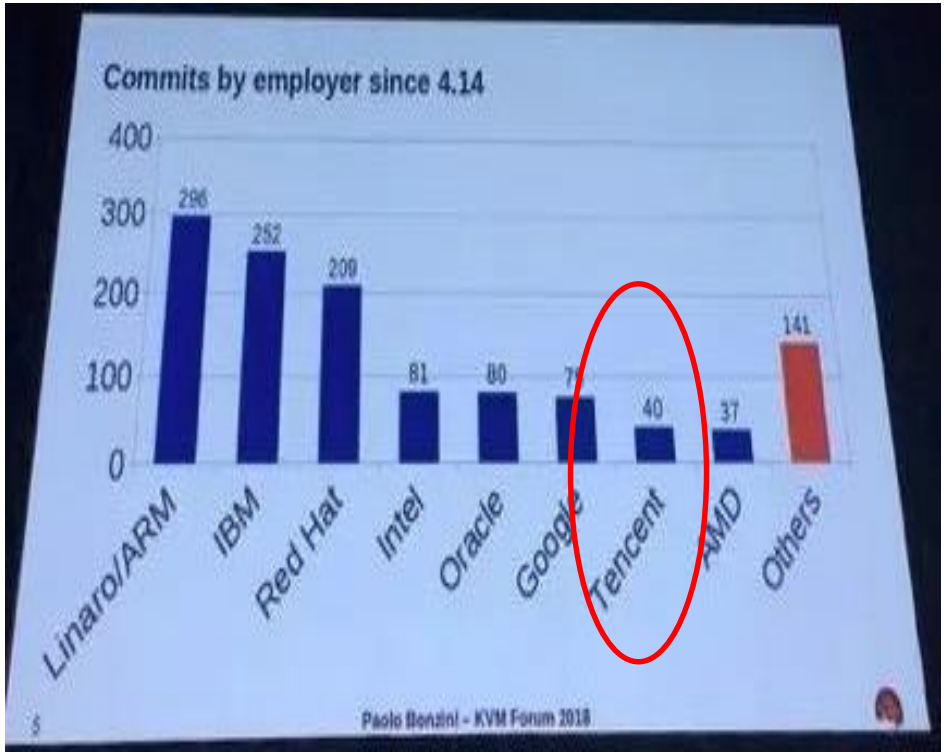


As shown in the charts:

After optimization, the 36.79% futex in the left chart was eliminated, the 56.15% file I/O overhead was reduced to 19.16% under the same stress, and slave I/O threads were optimized to I/O bound threads.

Cloud CDB Kernel-level Replication and Optimization

5.2.1 Tencent Cloud: A Global Contributor to KVM



- **Tencent Cloud KVM virtualization technology leads the world**

In 2018, Tencent Cloud contributed 40 patches to the KVM kernel, ranking 7th in the world. It is the second time Tencent Cloud was named in the KVM contributors list. Tencent Cloud is the only contributor from Mainland China on the list.

- **Contributed to one of the five core KVM breakthroughs in 2018**

The performance optimization solutions proposed by Tencent Cloud, including PV TLB shootdown and PV IPI, can enhance the performance of high-end VMs by reducing virtualization layer loss. In some cases, this improvement can be as high as 130% to 150%.

5.2.1 Tencent Cloud Broke Four Performance Testing World Records

- Gray Sort: Sorted 100 TB of data in 98.8 seconds.
- Minute Sort: Sorted 55 TB of data in 60 seconds.

Top Results

	Daytona	Indy
Gray	2016, 44.8 TB/min **Tencent Sort** 100 TB in 134 Seconds 512 nodes x (2 OpenPOWER 10-core POWER8 2.926 GHz, 512 GB memory, 4x Huawei ES3600P V3 1.2TB NVMe SSD, 100Gb Mellanox ConnectX4-EN) Jie Jiang, Lixiong Zheng, Junfeng Pu, Xiong Cheng, Chongqing Zhao Tencent Corporation Mark R. Nutter, Jeremy D. Schaub	2016, 60.7 TB/min **Tencent Sort** 100 TB in 98.8 Seconds 512 nodes x (2 OpenPOWER 10-core POWER8 2.926 GHz, 512 GB memory, 4x Huawei ES3600P V3 1.2TB NVMe SSD, 100Gb Mellanox ConnectX4-EN) Jie Jiang, Lixiong Zheng, Junfeng Pu, Xiong Cheng, Chongqing Zhao Tencent Corporation Mark R. Nutter, Jeremy D. Schaub
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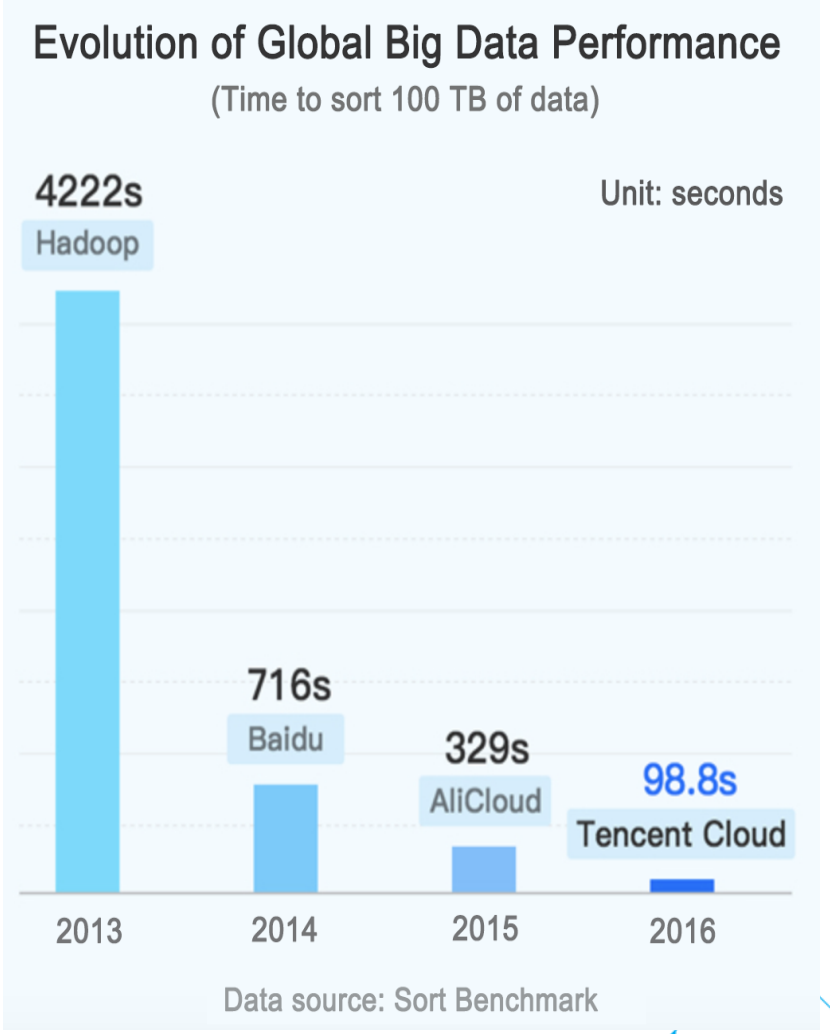
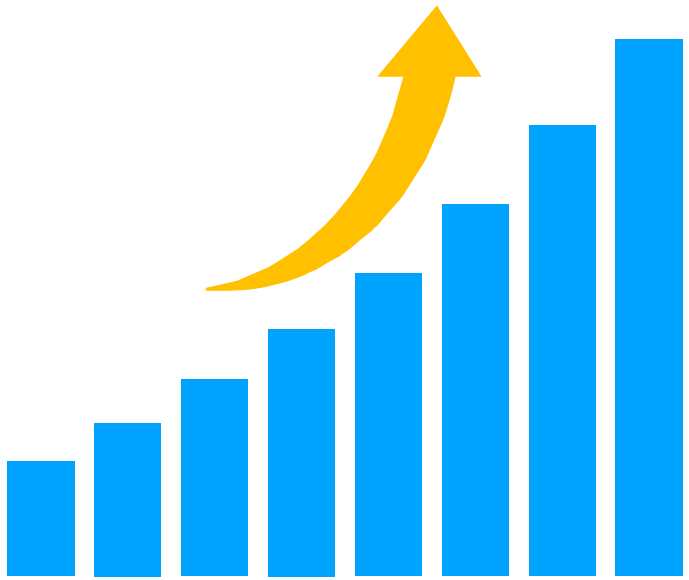


5.2.2 Procurement Capabilities

- Data center construction costs
- System and software procurement costs
- Long cycle, high time costs
- Operation staff costs



5.2.3 Service Delivery

SaaS
(Software as a Service)

Facial recognition | **Voice assistance** | **Video services** | **…**

PaaS
(Platform as a Service)

Cloud databases | **Cloud cache** | **Cloud Object Storage** | **…**

IaaS
(Infrastructure as a Service)

CVM | **Cloud Load Balancer** | **Cloud Block Storage** | **…**

5.3 Tencent Cloud Success Stories

100,000+ enterprise clients and **2 million+** long tail customers

- Government
- Finance
- Retail
- E-commerce
- Education
- Streaming
- Gaming

Quiz

- Hybrid cloud, combining public clouds and private clouds with interconnection, is one of the latest trends in cloud computing. What are the forces driving the development of hybrid clouds and what are the challenges faced by this technology?

Course Summary

This course covered the following topics:

- The evolution of data centers: EDCs, IDCs, and Cloud Computing
- The key features of cloud computing: Five features, four deployment methods, and three service modes
- Key cloud computing technologies: Computing virtualization, distributed storage, network virtualization, cloud management platforms, containers, AI, and big data
- The impact and market of cloud computing: Development history of cloud computing, Industrial Internet, and the features of mainstream cloud vendors
- The development and advantages of Tencent Cloud: Development history, competitive advantages, and success stories

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Thank you