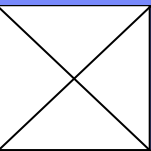


Advanced web technology

Web高级开发与应用技术

服务web与云计算概述



服务概念的提出

*“ As a result of the changes in how businesses and consumers use the Web, the industry is converging on a new computing model that enables a **standard** way of building applications and processes to **connect and exchange** information **over the Web**. ”*

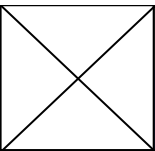
Bill Gates - 1999

Software as a service

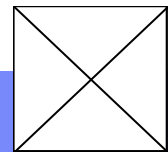
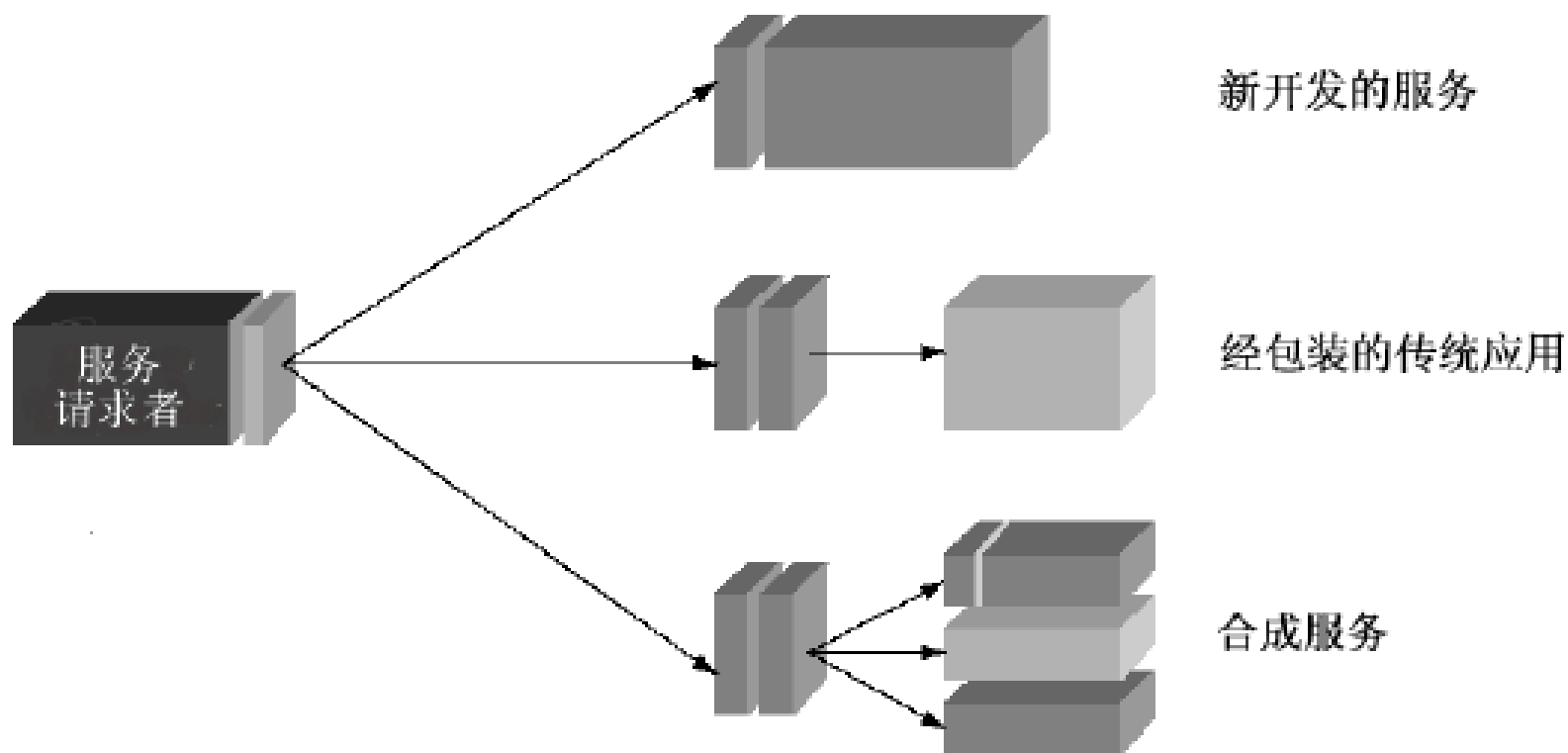
. . .



Truly programmable Web

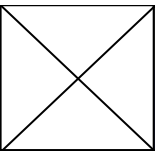
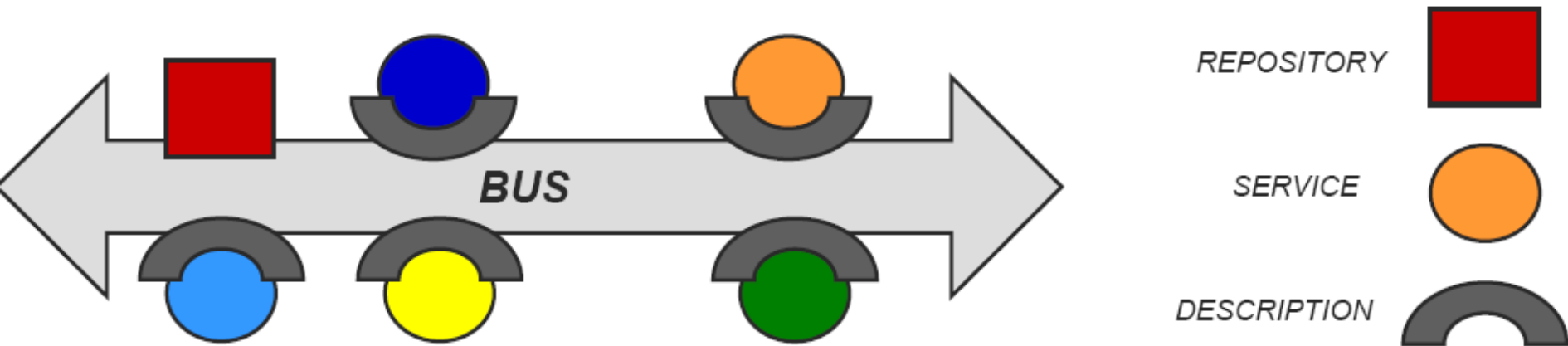


将软件与服务分离



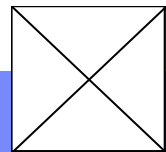
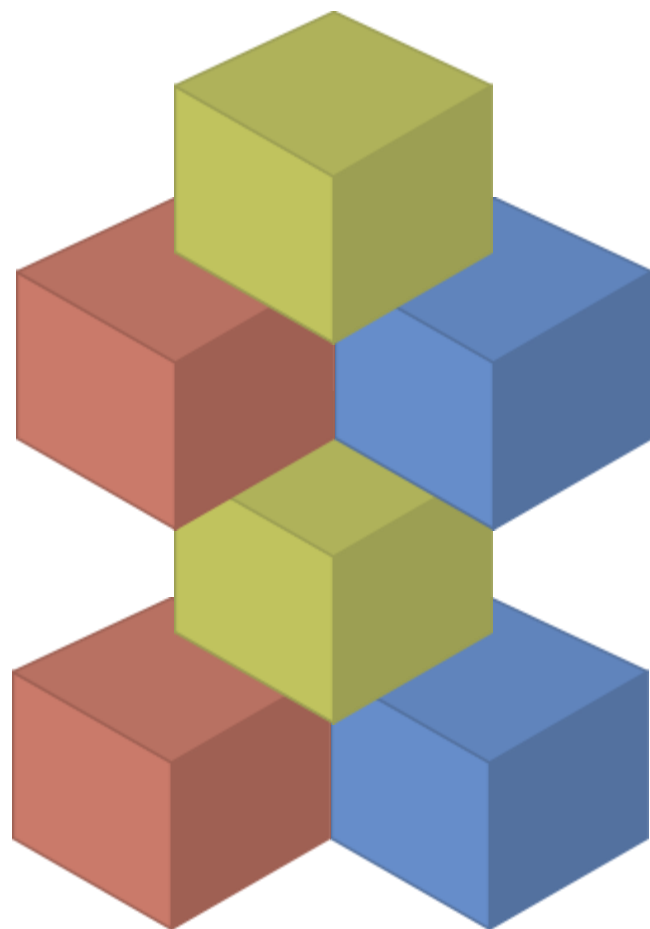
SOA是什么？

- W3C : A set of components which can be invoked, and whose interface descriptions can be published and discovered.

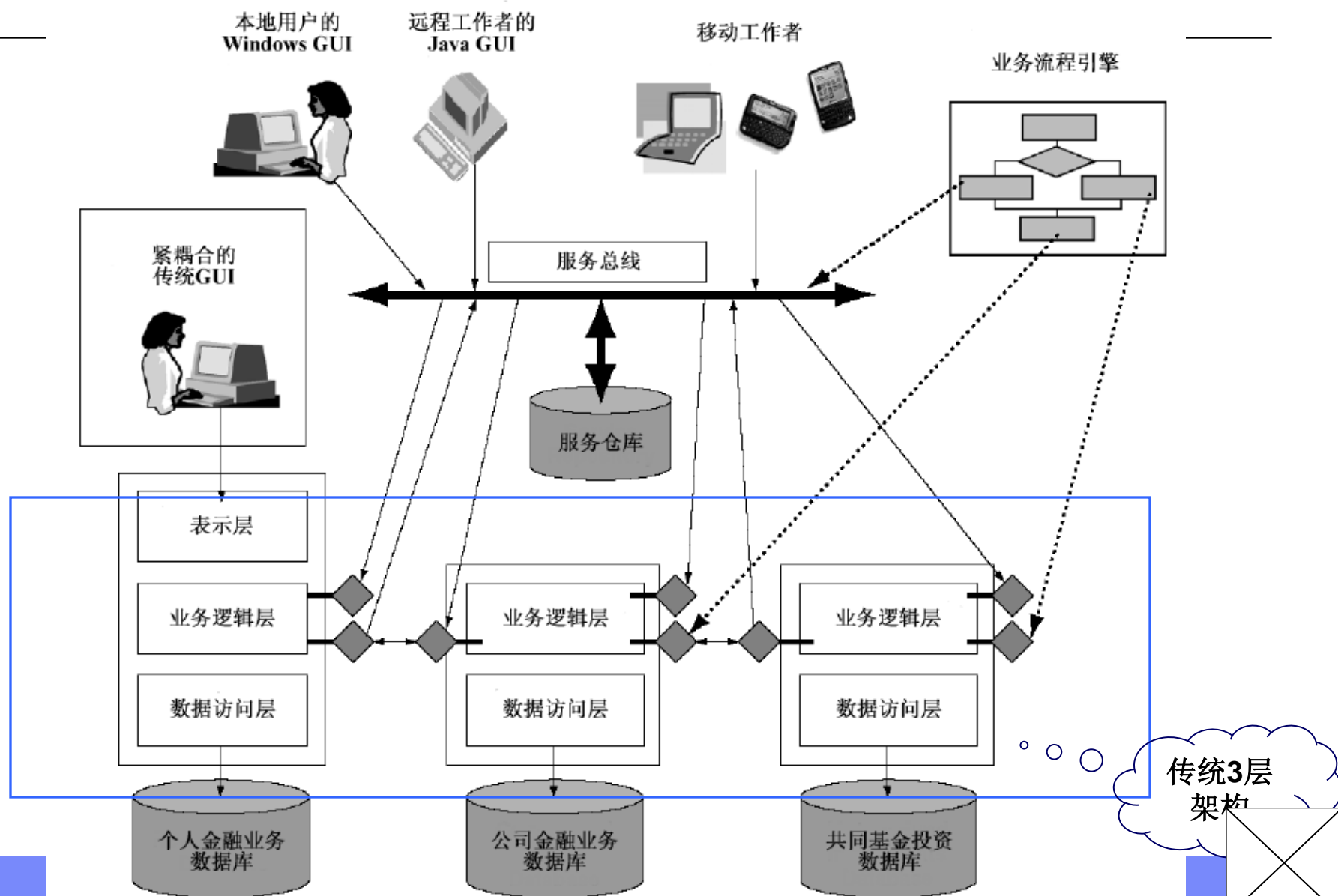


什么是面向服务的体系架构？

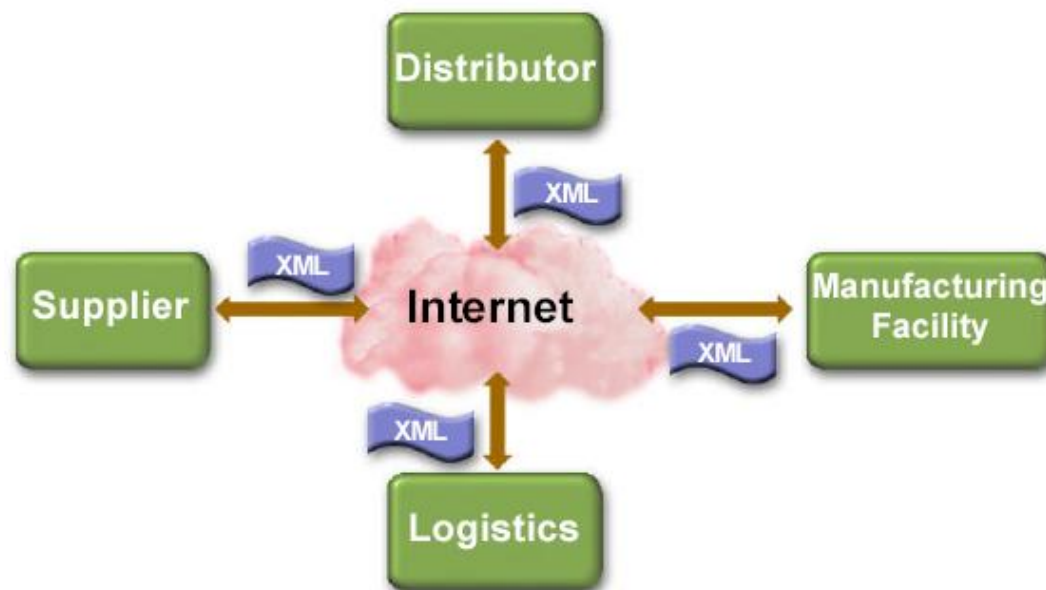
- 一个组件模型
- 将应用程序的不同功能单元（*服务*）通过这些服务之间定义良好的接口和契约联系起来。
- 接口是采用中立的方式进行定义的，它应该独立于实现服务的硬件平台、操作系统和编程语言。
- 构建在各种这样的系统中的服务可以以一种统一和通用的方式进行交互。



面向服务的集成示例



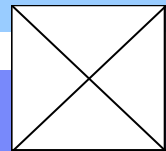
Web Services的产生



“Growing need for a **standard lightweight infrastructure** for data exchange in e-business applications.”

1999年, HP(惠普)公司成为了第一个引入Web服务概念的软件供应商。

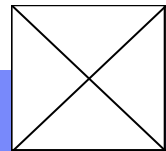
2000年6月Microsoft提出了“Web服务”这个术语, 并把Web服务作为了它的.NET计划的一个重要组件



Web Services

■ Web Services的发展原动力

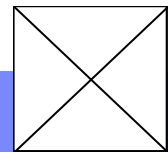
- 电子商务和企业应用集成的发展，日趋基于Web应用：
 - 从局部化发展到全球化
 - 从B2C（Bussiness-to-Costumer）发展到B2B（Bussiness-to-Bussiness）
 - 从集中式发展到分布式
- 需要解决 **语言差异、平台差异、协议差异、数据差异** 所带来的高代价的系统集成



Web Services

■ Web Service概述

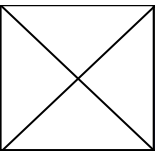
- **Web Services是一个崭新的分布式计算模型**
- **Web Services是一系列标准的集合**
 - SOAP
 - WSDL
 - UDDI
 - WSFL
 - ...
- **Web Services架构提供一个松散耦合的分布式计算环境**



web services

Web Services Definition by W3C

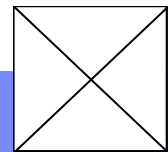
- A Web service is a **software application**
- identified by a **URI**,
- whose **interfaces and binding** are capable of being defined, described and discovered by **XML artifacts** and
- supports direct **interactions** with other software applications
- using **XML based messages**
- via **internet-based protocols**



web services

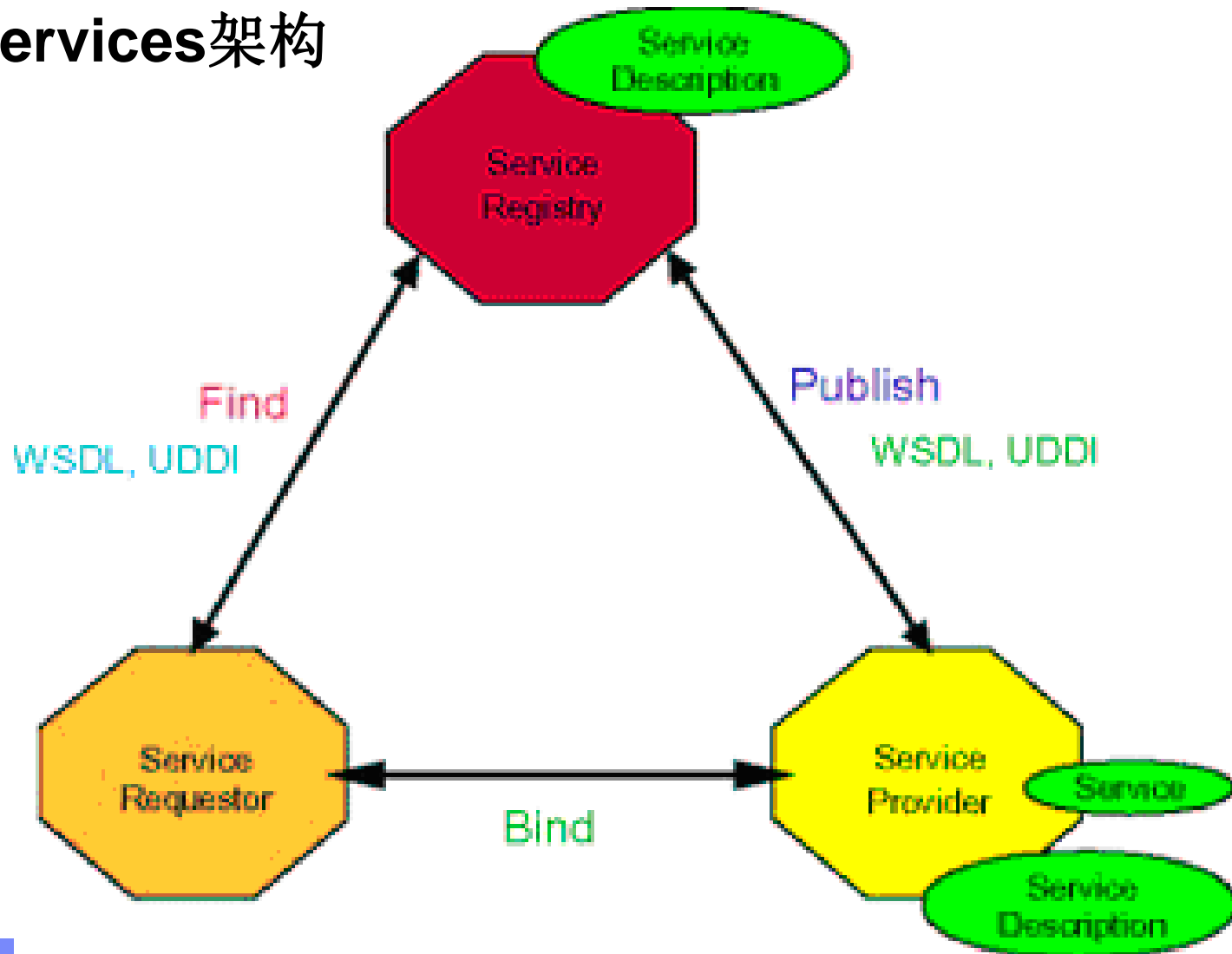
- W3C2004 年2 月发布的面向服务架构规范中定义

单个的**Web** 服务，就是一个支持机器之间通过网络进行交互的软件系统。**Web** 服务使用机器可以处理的格式（特别是**WSDL**）来描述自己的接口。其他系统则依据该接口描述，使用**SOAP** 报文格式与**Web** 服务通信。典型的**SOAP** 报文是一个利用**HTTP** 传输的**XML** 序列，在传输中通常与其他**Web** 相关的标准结合



Service Web

■ Web services架构



Web Service架构

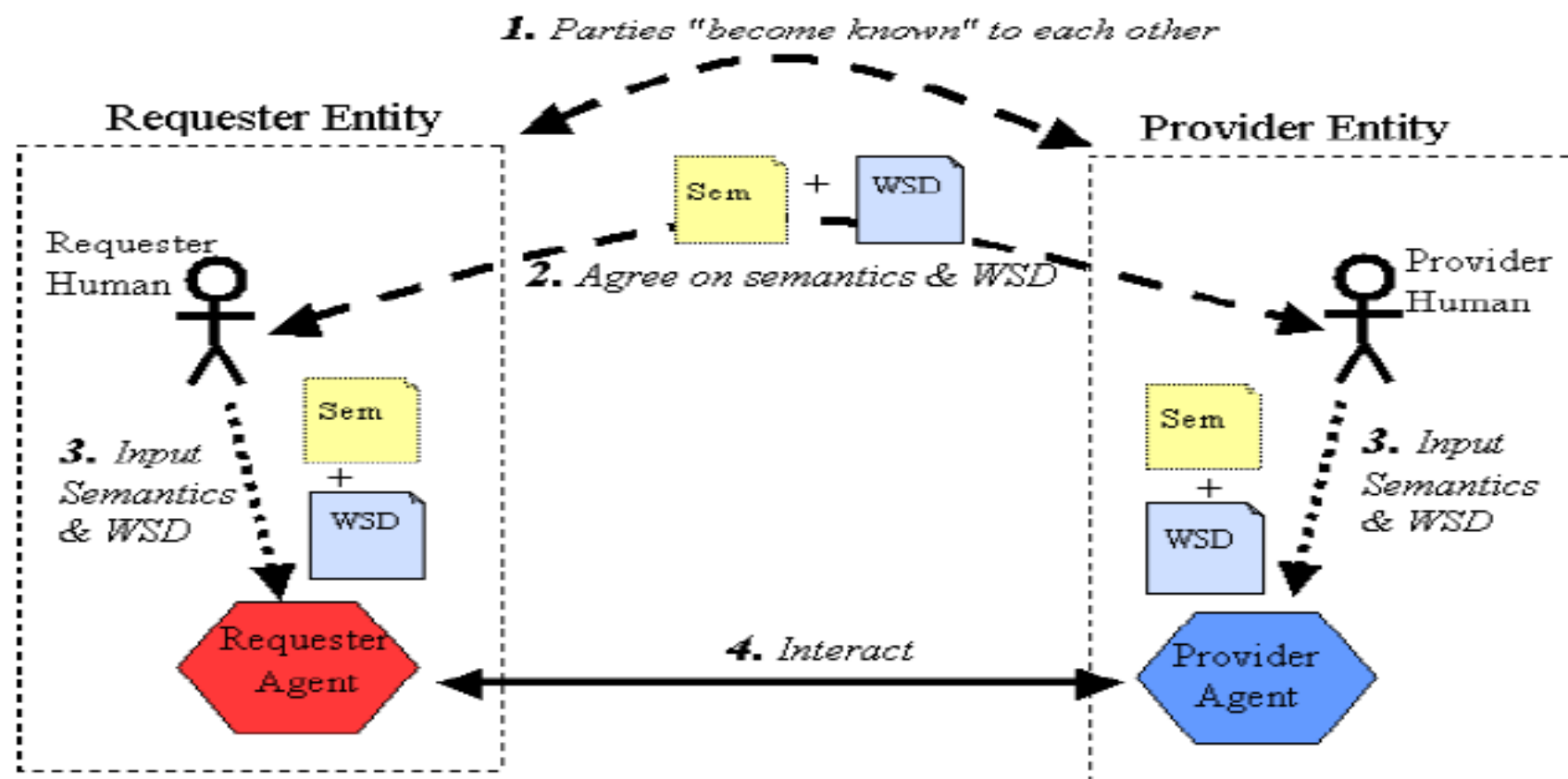
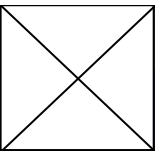
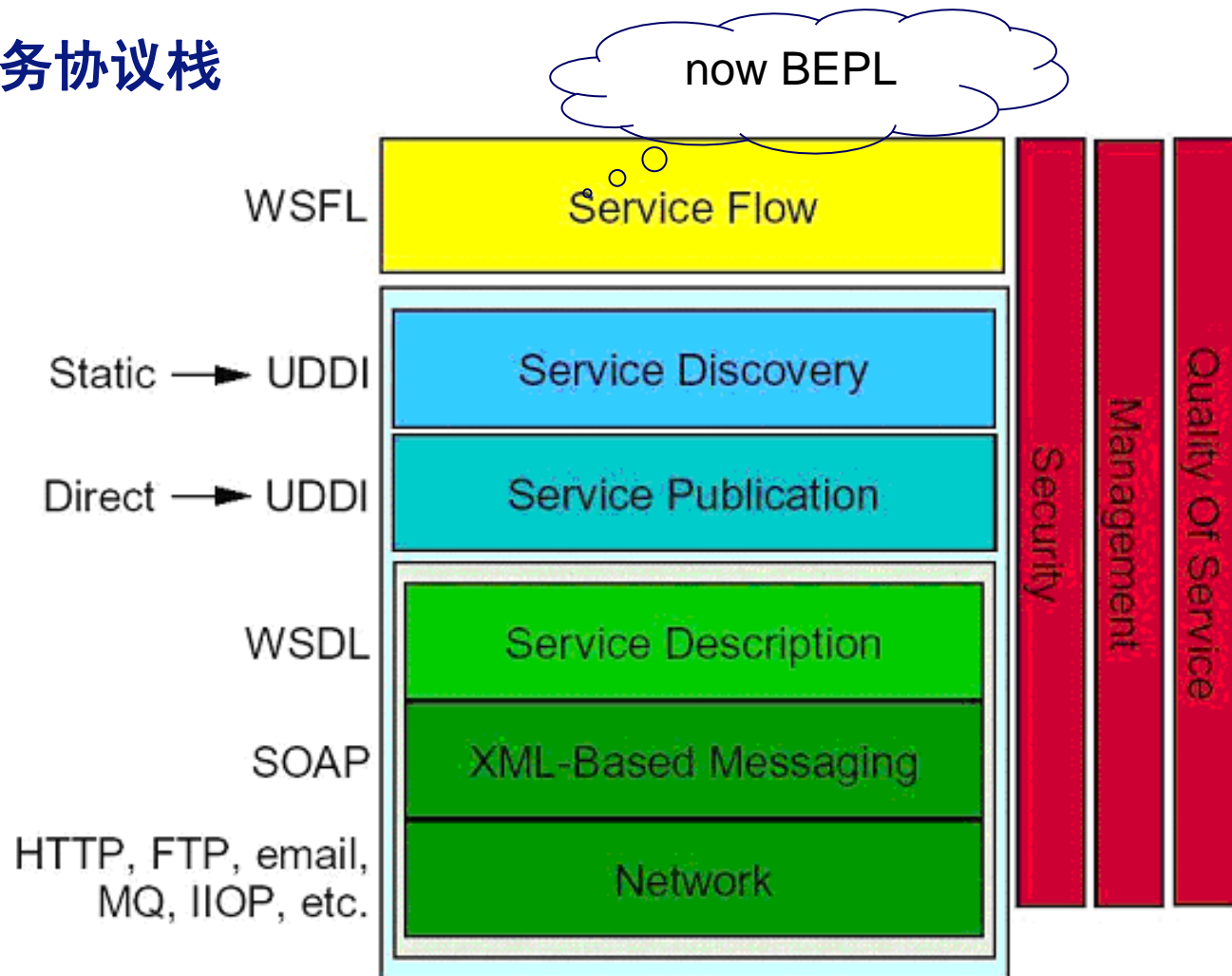


图 3.1. Web 服务的架构 (SOA) ^[16] (2004.2.11 由 W3C 发布)

Web Service架构

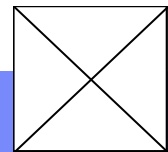
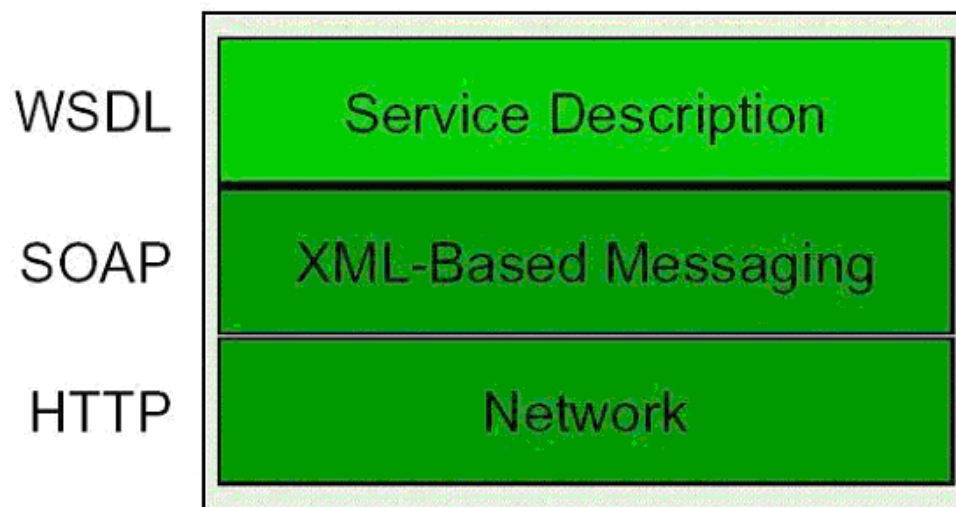
■ Web 服务协议栈



Web Service架构

■ 可互操作的基础协议栈

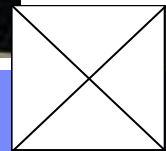
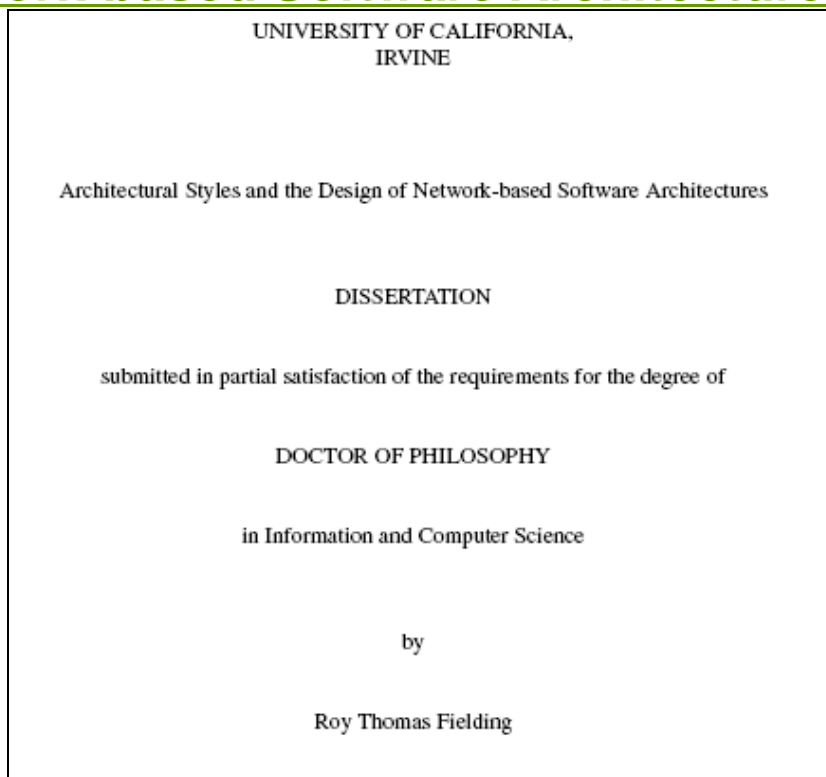
- 简单的协议栈将包括网络层的 HTTP、XML 消息传递层的 SOAP 协议以及服务描述层的 WSDL。
- 所有企业间或公用 Web 服务都应该支持这种可互操作的基础协议栈



REST化的Web

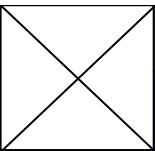
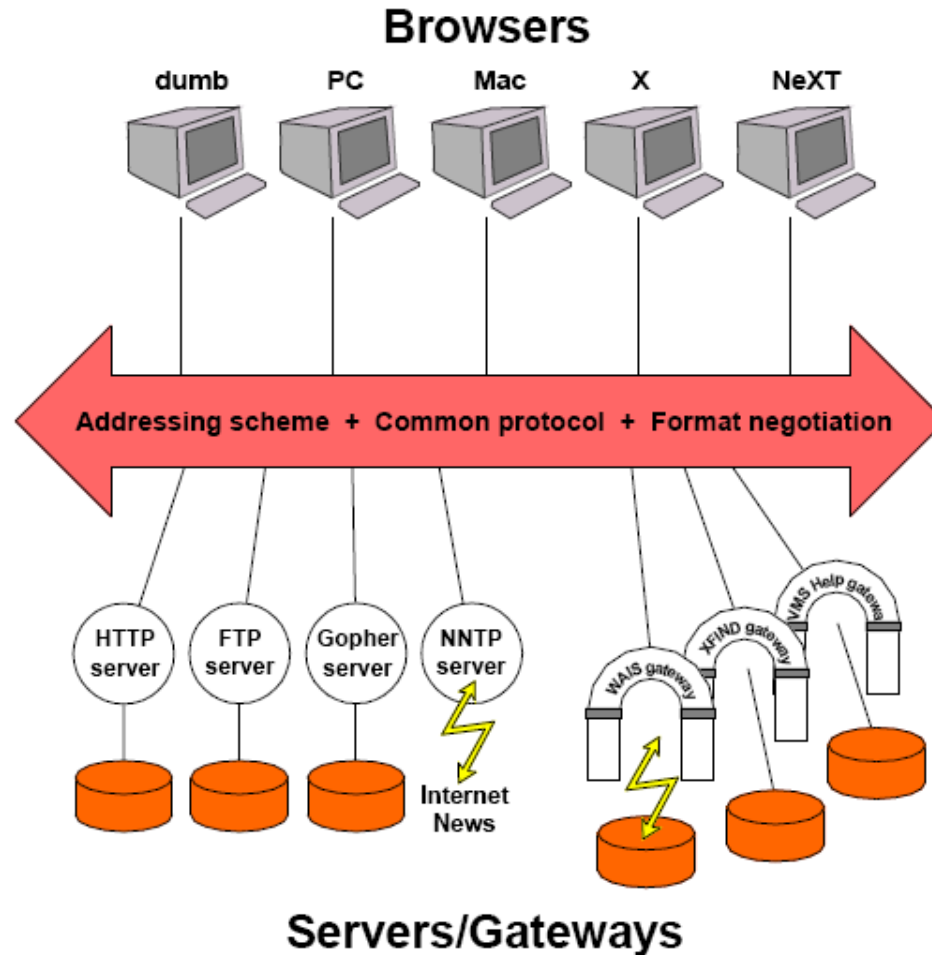
■ REST是什么

- **Representational State Transfer** （“表述性状态转移”）
- **Roy Fielding**博士论文《Architectural Styles and the Design of Network-based Software Architectures》提出的一种web架构



REST化的Web

- 早期的Web架构，是通过客户-缓存-无状态-服务器的约束集合来定义的。



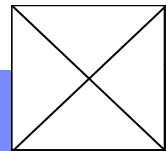
REST化的Web

- 表述性状态转移（**REST**）风格是对分布式超媒体系统中的架构元素的一种抽象。

这个名称“表述性状态转移”是有意唤起人们对于在一个良好设计的**Web**应用如何运转的印象：一个由网页组成的网络（一个虚拟状态机），用户通过选择链接（状态转移）在应用中前进，导致下一个页面（代表应用的下一个状态）被转移给用户，并且呈现给他们，以便他们来使用。

万维网是一个简单而灵活的分布式编程环境

human web和programmable web(基于Http和XML)没有本质区别

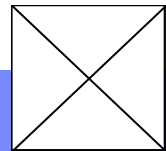


REST化的Web

■ REST是什么

– 分布式超媒体系统设计的一种架构风格

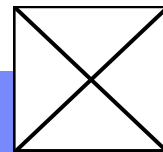
- 网络上的所有事物都被抽象为资源（resource）；
- 每个资源对应一个唯一的资源标识符（resource identifier）；
- 通过通用的连接器接口（generic connector interface）对资源进行操作；
- 对资源的各种操作不会改变资源标识符；
- 所有的操作都是无状态的（stateless）。
- 基于Http协议的，任何对资源的操作行为都是通过Http协议来实现



REST化的Web

■ 数据对象和HTTP方法的对应关系

数据对象操作	HTTP方法	对应关系说明
CREATE	POST	资源的创建
RETRIEVE (SELECT)	HEAD、GET	资源的查询、读取
UPDATE	PUT	资源的更新
DELETE	DELETE	资源的删除



RESTful Web Services

■ REST关键原则

– 为所有“事物”定义ID

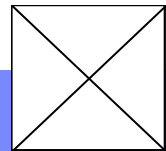
- 使用**URI** (依靠某个已被定义, 在全球范围中几乎完美运行, 并且能被绝大多数人所理解的规则)标识所有值得标识的事物, 特别是应用中提供的所有“高级”资源, 无论这些资源代表单一数据项、数据项集合、虚拟亦或实际的对象还是计算结果等。
- 使用唯一、全局统一的命名规则的好处, 既适用于浏览器中的Web应用, 也适用于机对机 (machine-to-machine, m2m) 通信。

```
http://example.com/customers/1234
```

```
http://example.com/orders/2007/10/776654
```

REST定义了应该如何正确地使用(这和大多数人的实际使用方式有很大不同) Web标准, 例如HTTP和URI。如果你在设计应用程序时能坚持REST原则, 那就预示着你会得到一个使用了优质Web架构(这将让你受益)的系统。

《深入浅出REST》by [Stefan Tilkov](#)



RESTful Web Services

■ REST关键原则

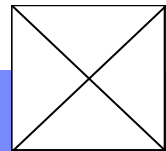
– 将所有事物链接在一起

- 超媒体被当作应用状态引擎
- 实际上服务器端为客户端（服务消费者）提供一组链接，使客户端能通过链接将应用从一个状态改变为另一个状态。

– 使用标准方法

- 使用**Http**操作
- **GET**方法具有幂等性[指多个相同请求返回相同的结果]
- 所有理解**HTTP**应用协议的组件能与你的应用交互

《深入浅出REST》by [Stefan Tilkov](#)



RESTful Web Services

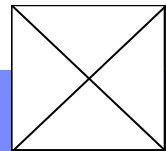
- **REST**关键原则

- 资源多重表述

- 如果客户程序知道如何处理一种特定的数据格式，那就可以与所有提供这种表述格式的资源交互
 - 同一个资源的不同表述，可以有利于不同的客户端。
 - 资源不仅可以被你的应用所用，还可以被任意标准**Web**浏览器所用

```
GET /customers/1234 HTTP/1.1  
Host: example.com  
Accept: application/vnd.mycompany.customer+xml
```

```
GET /customers/1234 HTTP/1.1  
Host: example.com  
Accept: text/x-vcard
```

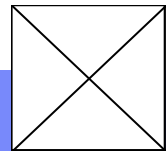


RESTful Web Services

- **REST关键原则**

- 资源多重表述

- **Xml**
 - **Json**
 - **Xhtml**
 - **RSS/Atom**
 - **Other Media types**



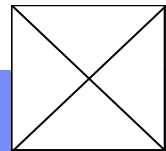
RESTful Web Services

- **REST**关键原则

- 无状态通信

- **REST**要求状态要么被放入资源状态中，要么保存在客户端上
 - 换句话说，服务器端不能保持除了单次请求之外的，任何与其通信的客户端的通信状态。这样做的最直接的理由就是可伸缩性
 - 无状态约束使服务器的变化对客户端是不可见的，因为在两次连续的请求中，客户端并不依赖于同一台服务器。

整体上来说Web、HTTP和URI仅仅是REST风格的一个主要实现。



RESTful WebServices的成功应用

– 客户端

– Ruby

- 面向对象的脚本语言
- 概念上类似smalltalk语言
- 编程风格类似perl

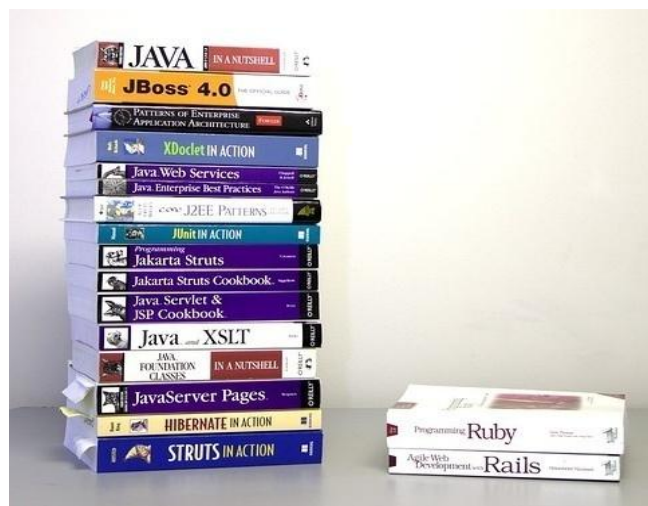
– Ruby On Rails

– Restlet(用于Java)

– Django(用于python)

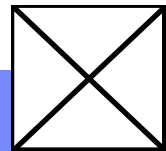
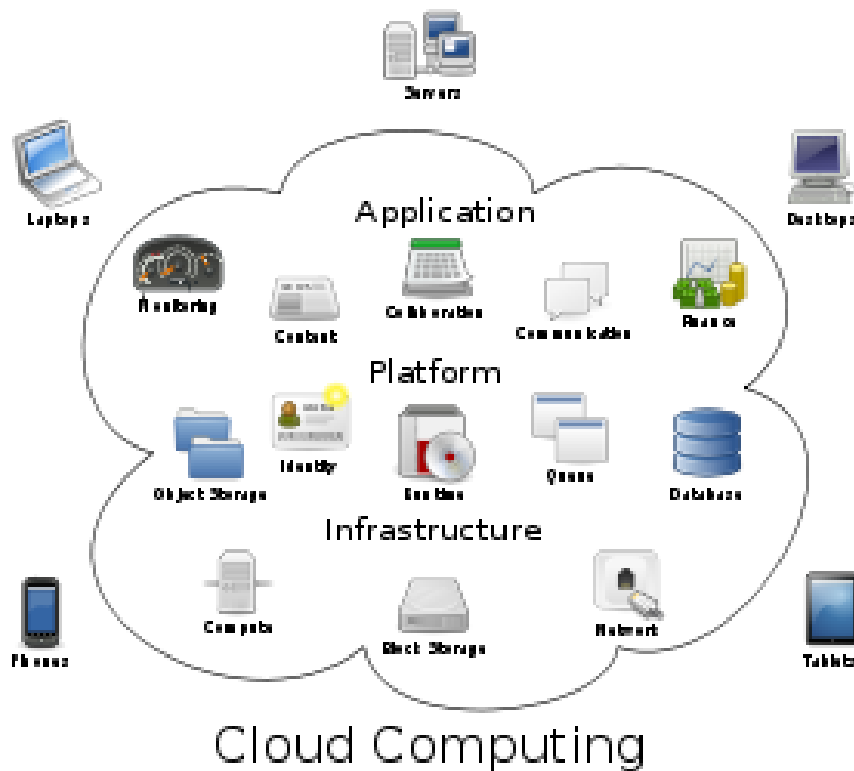
– 服务器端

– 目前主流的web服务, 如 Amazon S3等



云计算

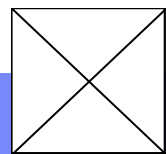
云计算是一种商业计算模型。它将计算任务分布在大量计算机构成的资源池上，使各种应用系统能够根据需要获取计算力、存储空间和信息服务。



云计算

指IT基础设施的交付和使用模式，指通过网络以按需、易扩展的方式获得所需的资源(硬件、平台、软件),提供资源的网络被称为“云”。

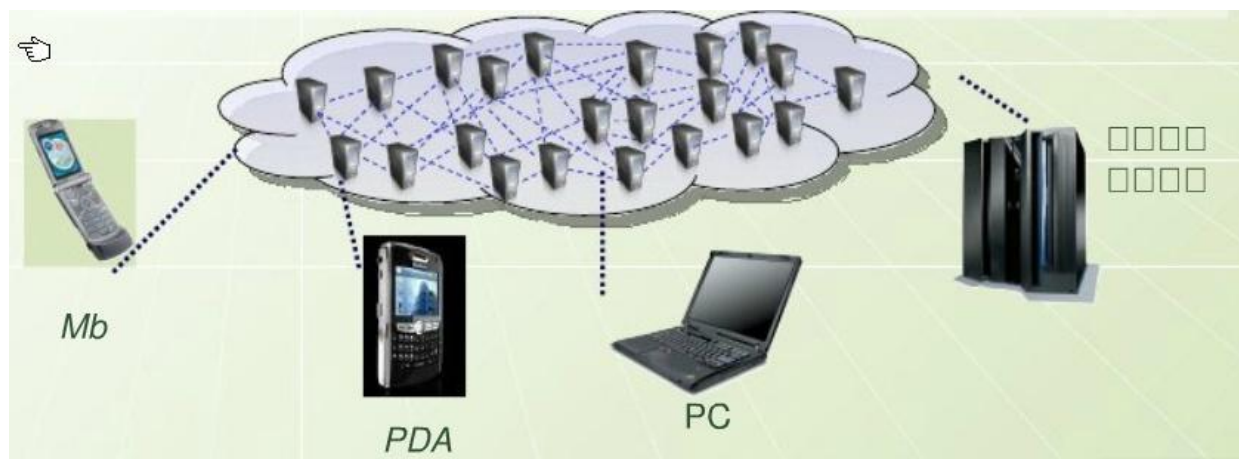
“云”中的资源在使用者看来是可以无限扩展的，并且可以随时获取，按需使用，随时扩展，按使用付费



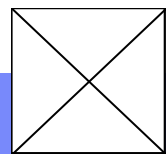
云计算

“云计算”(Cloud Computing)是分布式处理(Distributed Computing)、并行处理(Parallel Computing)和网格计算(Grid Computing)的发展, 或者说是这些计算机科学概念的商业实现。

云计算将IT相关的能力以服务的方式提供给用户, 允许用户在不了解提供服务的技术、没有相关知识以及设备操作能力的情况下, 通过Internet获取需要的服务

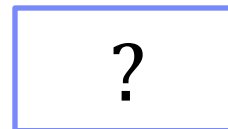


云计算相关演示



古老的预言重新接近正确？

“我认为全球大概只需要五台计算机就够了”



Microsoft®

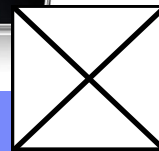


Thomas Watson



Bill Gates

“640KB内存应该对任何人都够用了。”

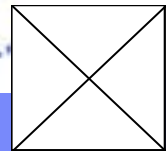


云计算发展历史

- 1983年，Sun Microsystems提出“The Network is the computer”。
- 20世纪90年代初，Ian Foster和Carl Kesselman提出了“网格”的概念。
- 2006年3月，亚马逊（Amazon）推出弹性计算云（Elastic Compute Cloud; EC2）服务。
- 2006年8月9日，Google行政总裁埃里克·施密特（Eric Schmidt）在搜索引擎大会（SES San Jose 2006）首次提出“云计算”（Cloud Computing）的概念。

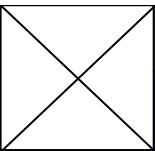


The Network is the Computer

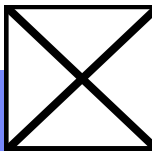
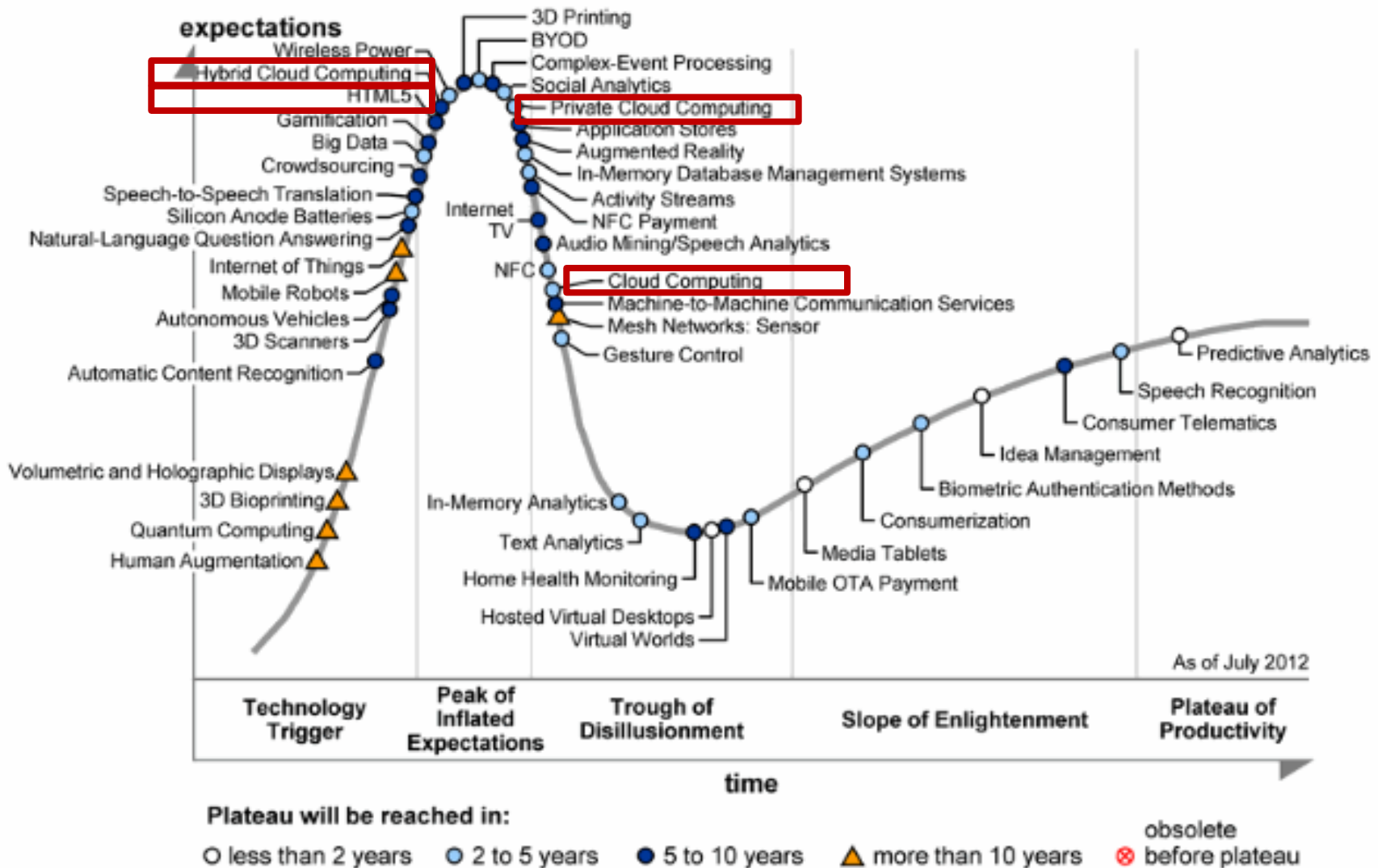


众说纷纭云计算

- **Reuven Cohen:** 云计算最简单的解释就是将其描述为“以互联网为中心的软件”。
- **Douglas Gourlay:** 云计算指的是一个大的宏图，基本上说，就是让用户透过 **Internet** 访问技术服务，现在，我每次登陆 **Facebook** 或搜索航班，事实上都是在使用云计算。
- **Damon Edwards:** 云计算还有很多令人费解的东西，然而不必如此复杂，只有三种服务是基于“云”的，**SaaS**，**PaaS** 和云计算平台。
- **Kevin Hartig (SUN):**云是一个庞大的资源池，你按需购买；云是虚拟化的；云可以象自来水，电，煤气那样计费。
- **Jan Pritzker:**云计算是用户友好的网格计算。
- **Aaron Ricadela:**当我们向不懂计算机技术的人提供虚拟技术的时候，我们希望虚拟或隐藏的是其复杂性。绝大多数人希望同应用或服务，而不是软件打交道。对于云计算，我们希望软件本身被虚拟或躲藏在系统或专业人员的背后，或者说“云”的背后。
- **Irving Wladawsky Berger:** 在我看来，云计算就是将以前那些需要大量软硬件投资以及专业技术能力的应用，以基于 **Web** 服务的方式提供给用户



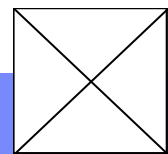
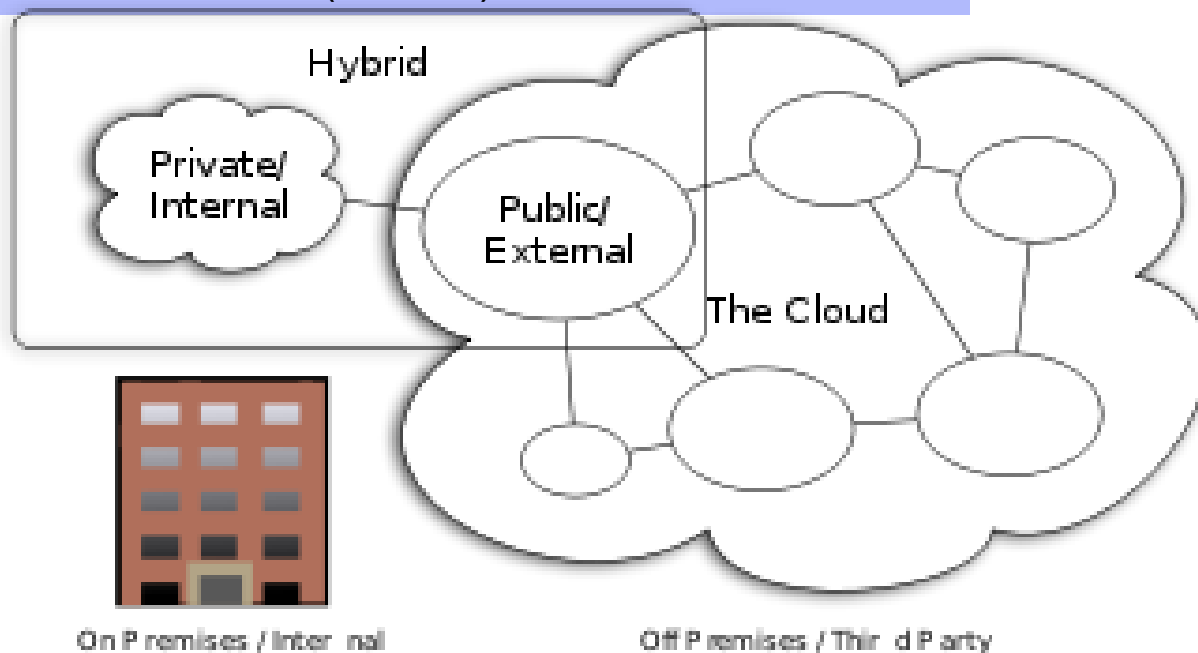
Hype Cycle for Emerging Technologies, 2012



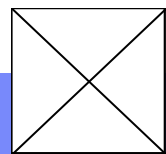
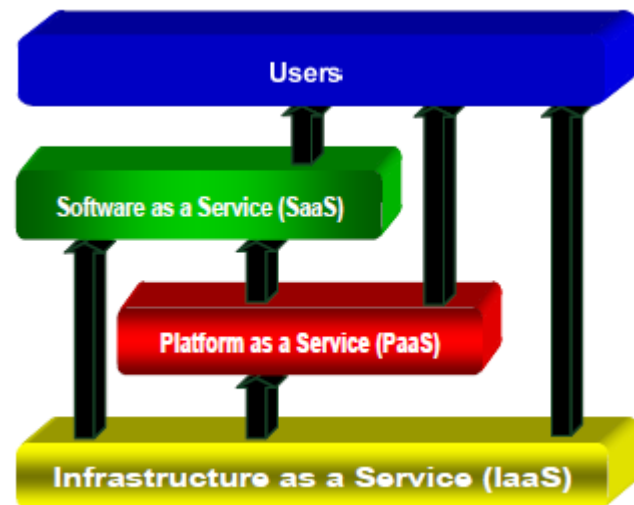
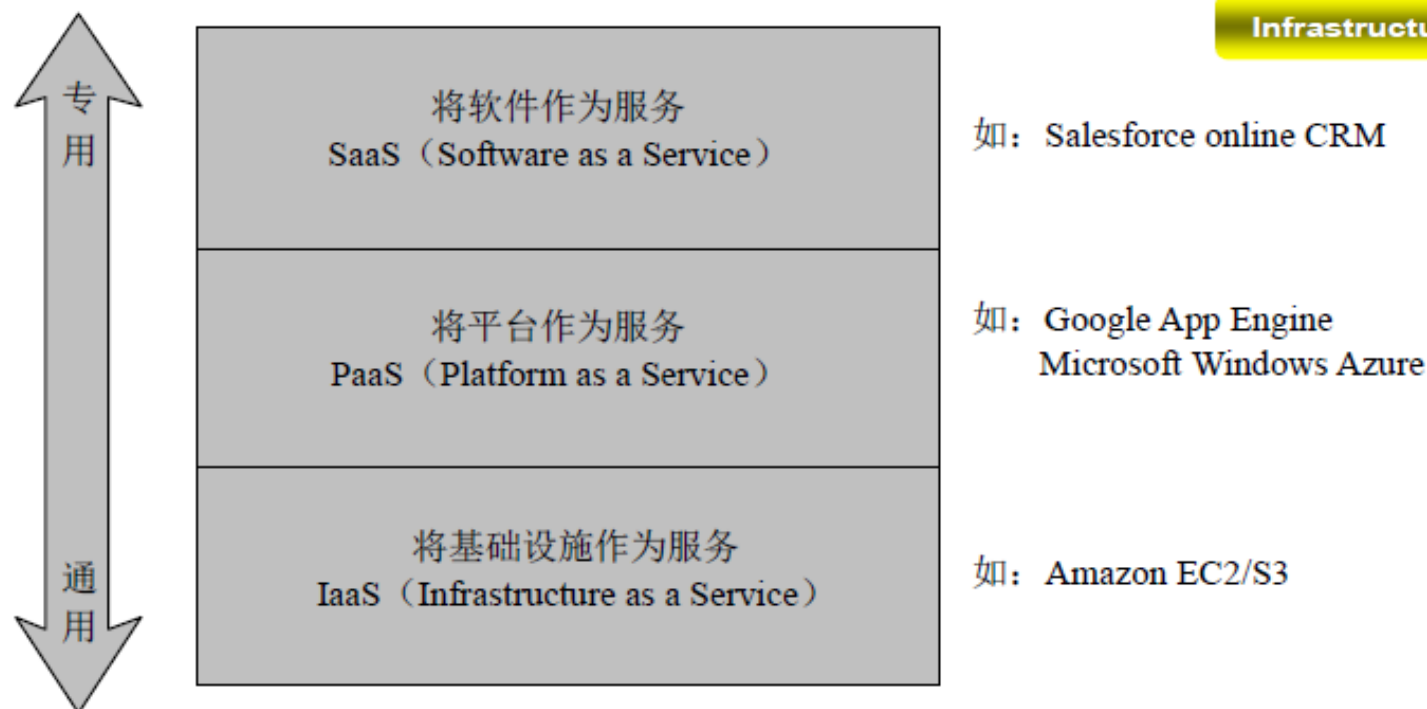
云计算的种类

- **公有云**: 给大众使用且具有庞大规模的基础设施
- **私有云**: 企业拥有或租用
- **社区云**: 共享社区基础设施
- **混合云**: 混合以上2种(或以上)部署模式

- **计算云**
- **存储云**



云计算的服务类型



云计算的特点

■ 云计算三要素

- 瘦客户端
- 网格计算
- 效用计算 (Utility computing)

超大规模

虚拟化

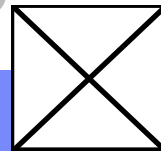
高可扩展性

高可靠性

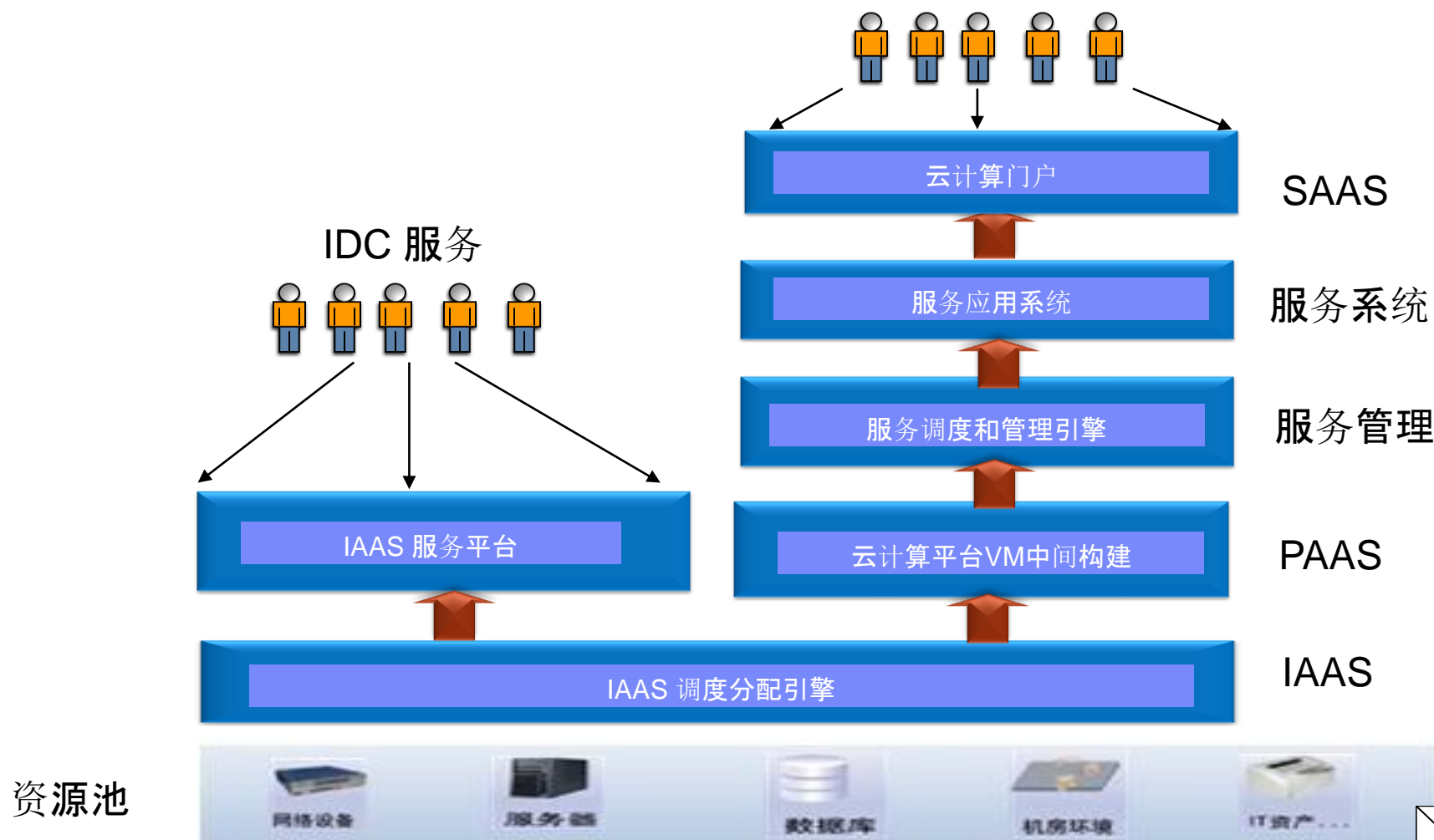
按需服务

通用性

极其廉价

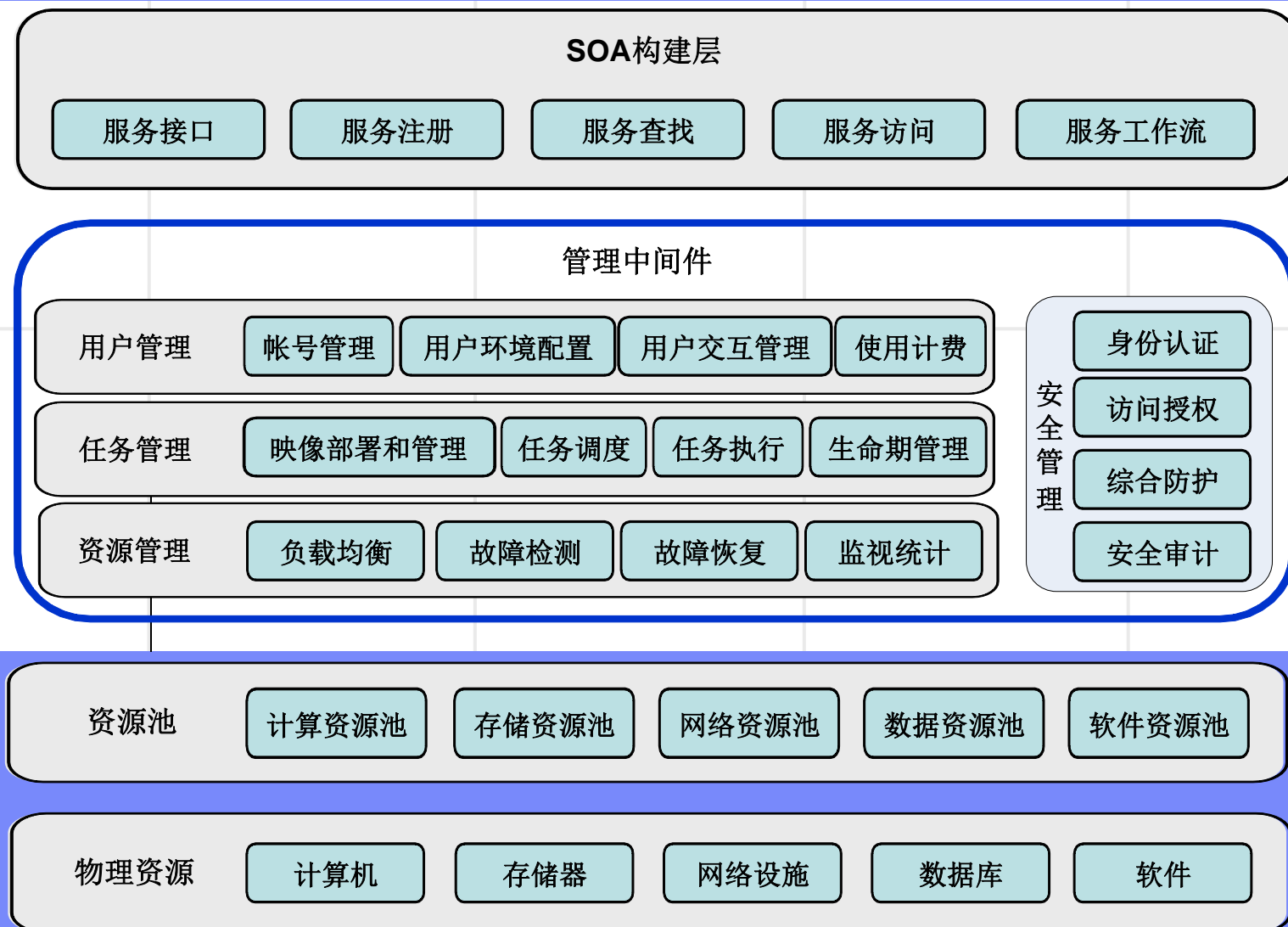


云计算技术体系结构

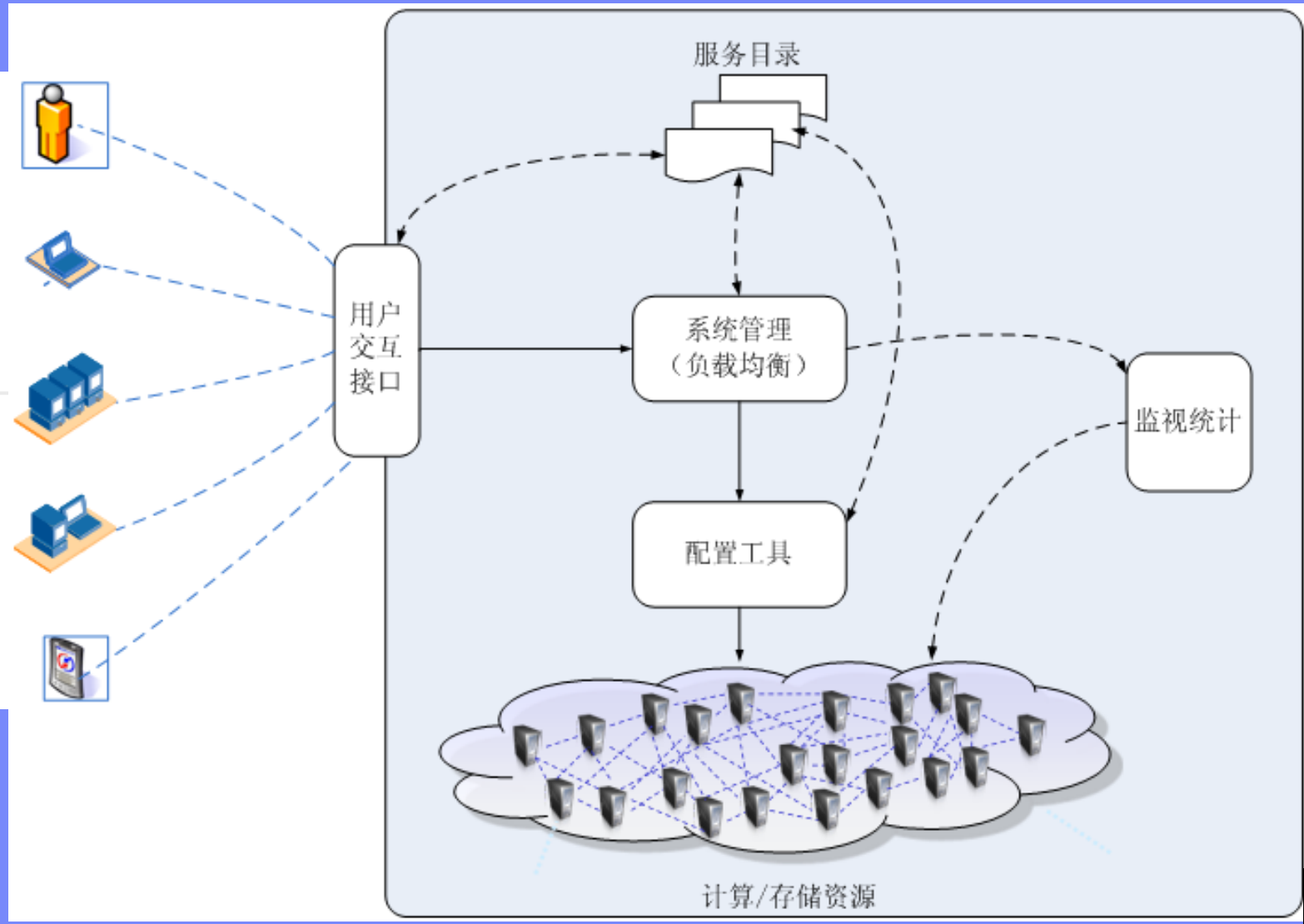


云计算技术体系结构

Advanced web technology



云计算实现机制



云计算下的Web堆栈

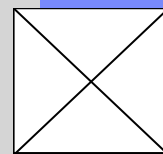
Advanced web technology

Netscape	Apache	lighttpd
BEA/SAP	PHP/Perl/Python	Hadoop
Oracle	MySQL	MogileFS
1998 年	2008 年	???

Lighttpd : 一种开放源 Web 服务器

Hadoop : 支持数据密集型分布式应用程序的免费 Java 软件框架

MogileFS: 一种能够在任意数量机器之间实现水平扩展的文件系统



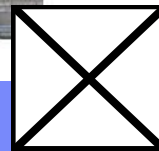
云计算计划



Microsoft®



集装箱中的“云”，搭积木般瞬间建设数据中心



云计算计划

■ Google

Google app engine

现状

优势

领先的服务端数据中心技术，极大的互联网访问量

不足

单一的盈利模式



推动云计算

转变用户习惯

使用软件->调用服务

丰富云端服务

地图, 办公, 视频。。

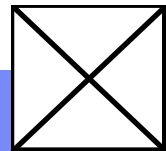


加强云终端力量

android

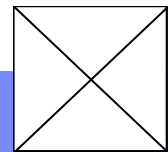
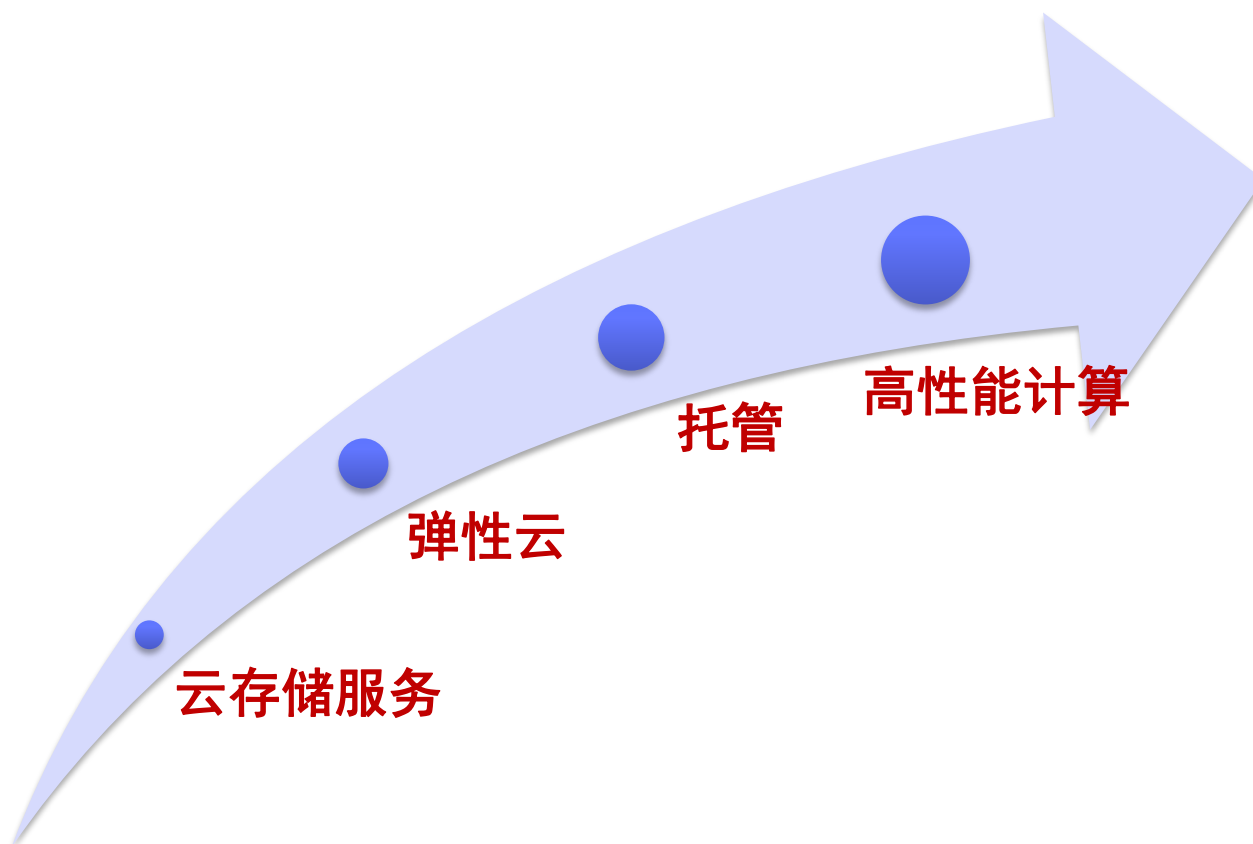
chrome os

并购moto



云计算计划

- Amazon-云时代的基础架构服务商
 - Amazon EC2 （Amazon Elastic Compute Cloud ）



Late Edition

New York. Today, sunny, a few after-
noon clouds. High 77°. Tonight, slightly
more humid. Low 61°. Tomorrow, sun
then clouds. High 81°. Yesterday, high
81, low 61. Weather map, Page C13.

U.S. ATTACK

HIJACKED JETS DESTROY TWIN TOWERS AND HIT PENTAGON IN DAY OF TERROR

A CREEPING HORROR

Buildings Burn and Fall
as Onlookers Search
for Elusive Safety

By N. R. KLEINFELD

It kept getting worse.
The horror arrived in episodic bursts of chilling disbelief, signified first by trembling floors, sharp eruptions, cracked windows. There was the actual unfathomable realization of a gaping, flaming hole in first one of the tall towers, and then the same thing all over again in its twin. There was the morose sight of bodies helplessly tumbling out, some of them in flames.
Finally, the mighty towers themselves were reduced to nothing. Dense plumes of smoke raced through the downtown avenues, coursing between the buildings, shaped like torpedoes on their sides. Every sound was cause for alarm. A plane appeared overhead. Was another one coming? No, it was a fighter jet. But was it friend or enemy? People craned their necks, but they didn't know where to go, should they go north, south, east, west? Stay outside, go indoors? People hid beneath cars and each other. Some contemplated jumping into the river.
For those trying to flee the very center of the collapsing World Trade Center towers, the most horrendous thought of all finally dawned on them: nowhere was safe.
For several panic-stricken hours yesterday morning, people in Lower Manhattan witnessed the inconceivable, the incomprehensible, the unthinkable. "I don't know what the game of hell looks like, but it's got to be like this," said John Maloney, a security director for an Internet firm in the trade center. "I'm a combat soldier in Vietnam, and I never saw anything like this."
The first warnings were small ones. Blocks away, Jim Farmer, a film composer, was having breakfast at a small restaurant on West Broadway. He heard the sound of a jet. An odd sound — too loud, it seemed, to be

Continued on Page A7

A Somber Bush Says Terrorism Cannot Prevail

By ELIZABETH BOMBLER

WASHINGTON, Sept. 11 — President Bush vowed tonight to retaliate against those responsible for today's attacks on New York and Washington, declaring that he would "make no distinction between the terrorists who committed these acts and those who harbor them."
"These acts of mass murder were intended to frighten our nation into chaos and retreat, but they failed," the president said in his first speech to the nation from the Oval Office. "Our country is strong. Terrorism acts can shake the foundation of our biggest buildings, but they cannot touch the foundation of America."
His speech came after a day of trauma that seems destined to define his presidency. Seeking to at once calm the nation and declare his determination to exact retribution, he gave a country numbed by repeated scenes of carnage that "these acts cannot stand, but they cannot dethrone the steel of American resolve."
Mr. Bush spoke only hours after returning from a sign-off course across the country. His Secret Service and military security teams moved him from Florida, where he woke up this morning expecting to press for his education bill, to command posts in Louisiana and Nebraska before it was determined the attacks had probably ended and he could safely return to the capital.
It was a sign of the catastrophic

Continued on Page A4



President Vows to Exact Punishment for 'Evil'

By SERGE SCHMEMMANN

Hijackers rammed jetliners into each of New York's World Trade Center towers yesterday, toppling both in a hellish storm of ash, glass, smoke and leaping victims, while a third jetliner crashed into the Pentagon in Virginia. There was no official count, but President Bush said thousands had perished, and in the immediate aftermath the calamity was already being ranked the worst and most audacious terror attack in American history.
The attacks seemed carefully coordinated. The hijacked planes were all en route to California, and therefore gorged with fuel, and their departures were spaced within an hour and 40 minutes. The first, American Airlines Flight 11, a Boeing 767 out of Boston for Los Angeles, crashed into the north tower at 9:03 a.m. Eighteen minutes later, United Airlines Flight 175, also headed from Boston to Los Angeles, plowed into the south tower at 9:59 a.m. Then an American Airlines Boeing 757, Flight 77, left Washington's Dulles International Airport bound for Los Angeles, but instead hit the western part of the Pentagon, the military headquarters where 24,000 people work, at 9:40 a.m. Finally, United Airlines Flight 93, a Boeing 737 flying from Newark to San Francisco, crashed near Pittsburgh, raising the possibility that its hijackers had failed in whatever their mission was.
There were indications that the hijackers on at least two of the planes were armed with knives. Attorney General John Ashcroft told reporters in the evening that the suspects on Flight 11 were armed that way. And Barbara Olson, a television commentator who was traveling on American Flight 77, managed to reach her father, Solicitor General Theodore Olson, by cell phone and to tell him that the hijackers were armed with knives and a box cutter.
In all, 366 people perished in the four plane crashes and several scores more were known dead elsewhere. Numerous firefighters, police officers and other rescue workers who responded to the initial disaster in Lower Manhattan were killed or injured when the buildings collapsed. Hundreds were treated for cuts, broken bones, burns and smoke inhalation.
But the real carnage was concealed for now by the twisted, smoking, ash-choked carcasses of the twin towers, in which thousands of people used to work on a weekday. The collapse of the towers caused another World Trade Center building to fall 7 hours later, and several

Continued on Page A4

Awaiting the Aftershocks

Washington and Nation Plunge Into Fight
With Enemy Hard to Identify and Punish

By R. W. APPLE JR.

WASHINGTON, Sept. 11 — In a sense of equilibrium, with warplanes and heavily armed helicopters circling overhead, past and present national security officials currently debated the possibility of a Congressional declaration of war — but against precisely whom and in what exact circumstances? Warships were maneuvering to protect New York and Washington. The North American Air Defense Command, which had seemed to many a relic of the cold war, adopted a posture of security and self-confidence that was shattered by the twin towers' suffering a grievous blow, from which recovery will be slow. The after shocks will be nearly as bad, as hundreds and possibly thousands of people discover that friends or relatives died awfully, fiery deaths.
Scenes of chaos and destruction evocative of the nightmare world of Hieronymus Bosch, with smoke and debris shooting out the nos, were carried by television into homes and workplaces across the nation. Echoing Francis D. Roosevelt's description of the attack on Pearl Harbor as an event "which will live in infamy," Gov. George E. Pataki of New York, a Republican, spoke of "a horrendous act of terrorism" and Senator Charles E. Schumer of New York, a Democrat, spoke of "a diabolical attack."
But more words were inadequate weapons to contain the sense of shock and horror that people felt.
As Washington struggled to regain



- 《纽约时报》
- 使用亚马逊云计算服务在不到24个小时的时间里处理了1100万篇文章转换成为 PDF 格式
- 累计花费240美元
- 如果用自己的服务器，需要数月和多得多的费用

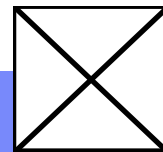
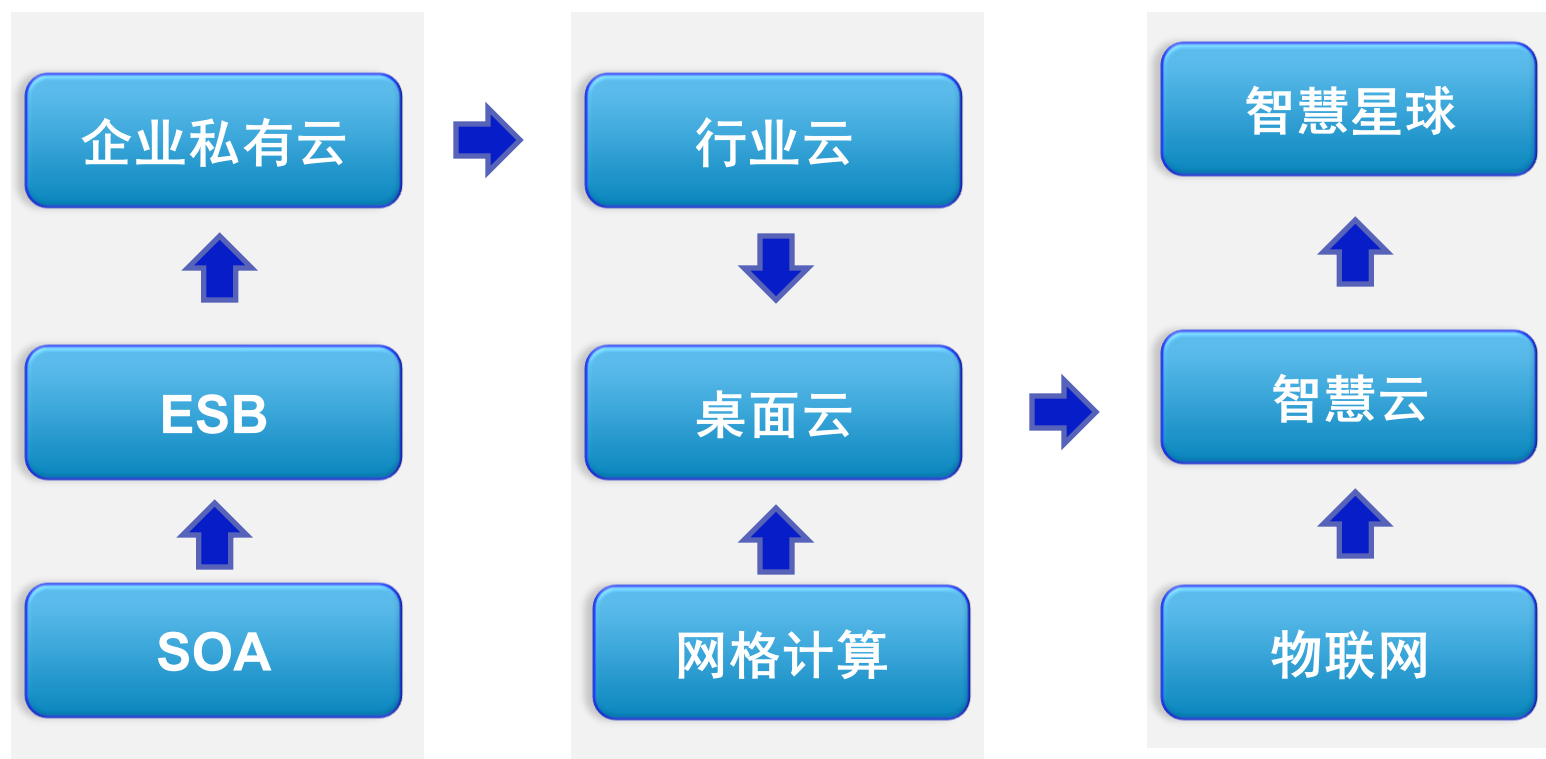
MORE ON THE ATTACKS

RESCUERS BECOME VICTIMS Firefighters who rushed to the trade center were killed. PAGE A2
SEARCH FOR SURVIVORS Some people trapped in the rubble for hours were rescued. PAGE A2
OFFICIALS SUSPECT BIN LADEN Law-enforcement intercepts after the attacks were cited. PAGE A3
TERROISTS EXPLOIT WEAKNESS Investigators had criticized precautions against hijacking. PAGE A3
CASUALTIES IN WASHINGTON An unknown number of people were killed at the Pentagon. PAGE A3



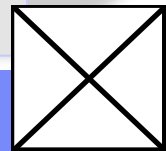
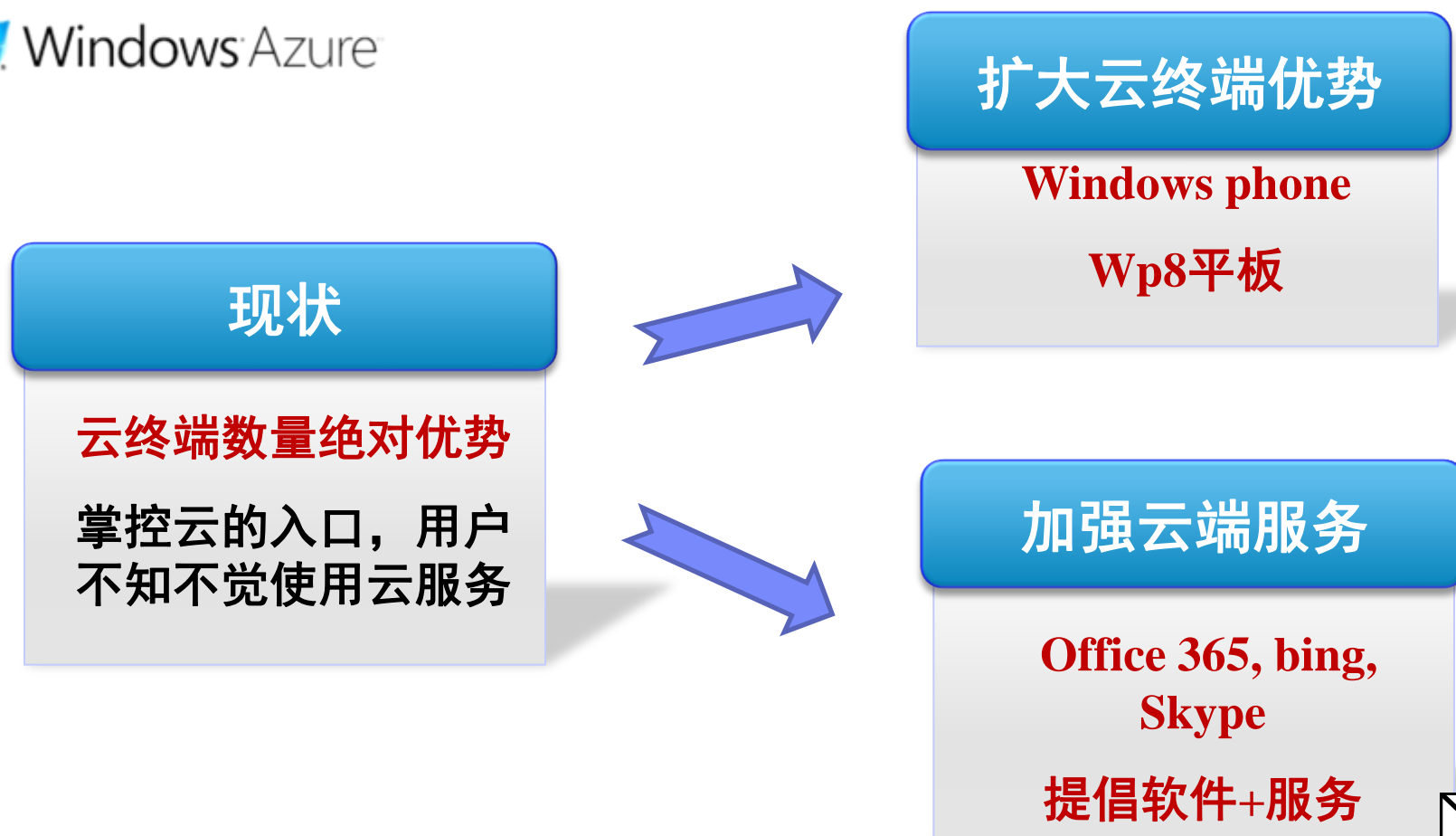
云计算计划

■ IBM蓝云（Blue Cloud）计算



云计算计划

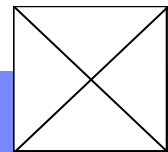
■ 微软



云计算计划

■ 微软

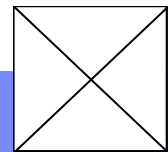
- Windows Azure是由微软所发展的一套云计算操作系统, 用来提供云在线服务所需要的操作系统与基础存储与管理的平台
- 一开始提供的是平台即服务 (PaaS), 2012 正式开放了基础建设即服务 (IaaS) 的相关解决方案。



Google云计算关键技术



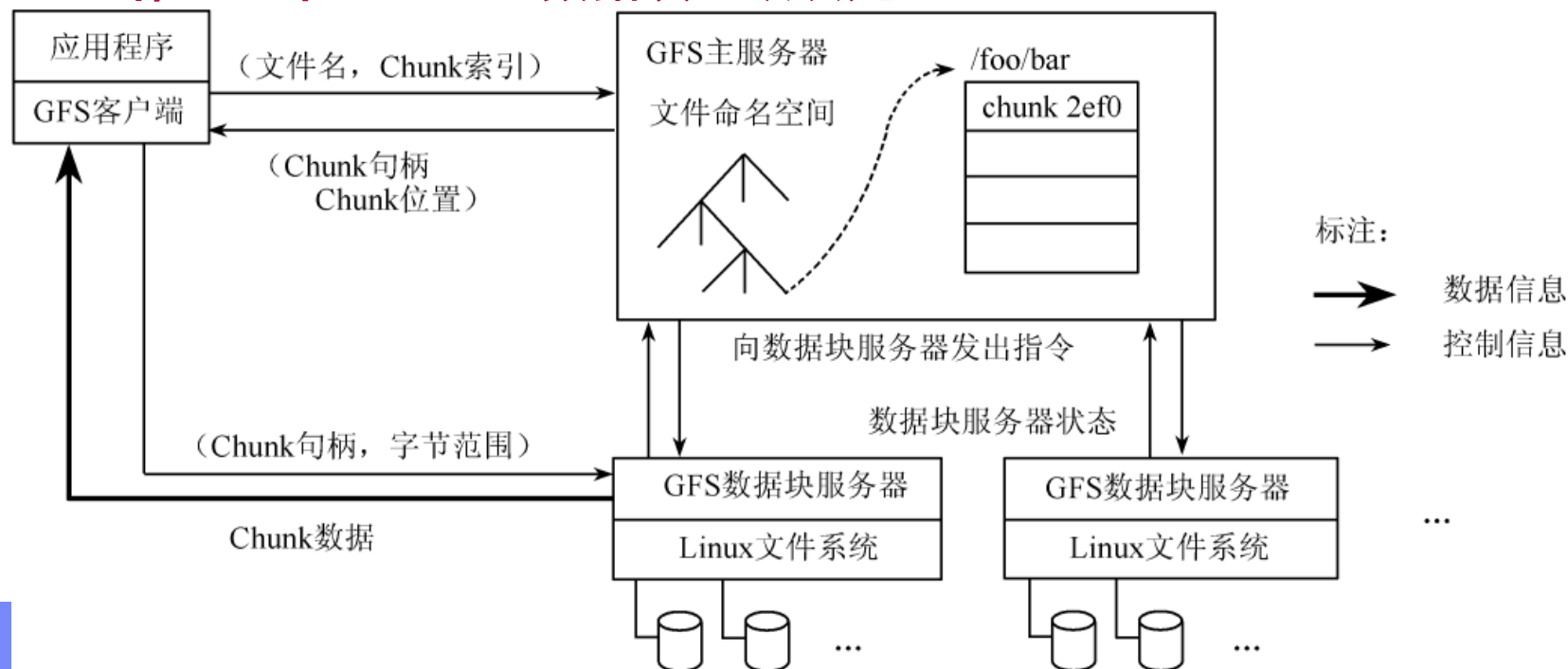
- Google文件系统GFS (Google File System)
- 并行数据处理MapReduce
- 结构化数据表BigTable
- 分布式锁管理Chubby



Google云计算关键技术

■ 分布式文件系统GFS:

- **Client（客户端）**:GFS以库文件提供给应用程序的访问接口
- **Master（主服务器）**:GFS的管理节点，在逻辑上只有一个，它保存系统的元数据，负责整个文件系统的管理
- **Chunk Server（数据块服务器）**:Chunk Server负责具体的存储工作。一个Chunk（数据块）默认是64MB



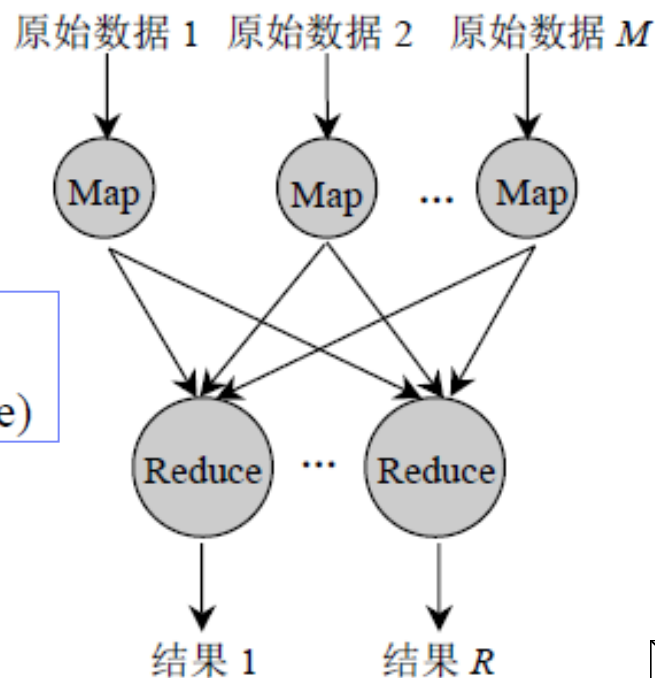
Google云计算关键技术

■ 并行数据处理模型MapReduce

- 特别适合于非结构化和结构化的海量数据的搜索、挖掘、分析与机器学习等;
- 封装了并行处理、容错处理、本地化计算、负载均衡等细节
- Map 与Map 之间是互相独立的
- 每个Reduce 所处理的Map 中间结果是互不交叉的

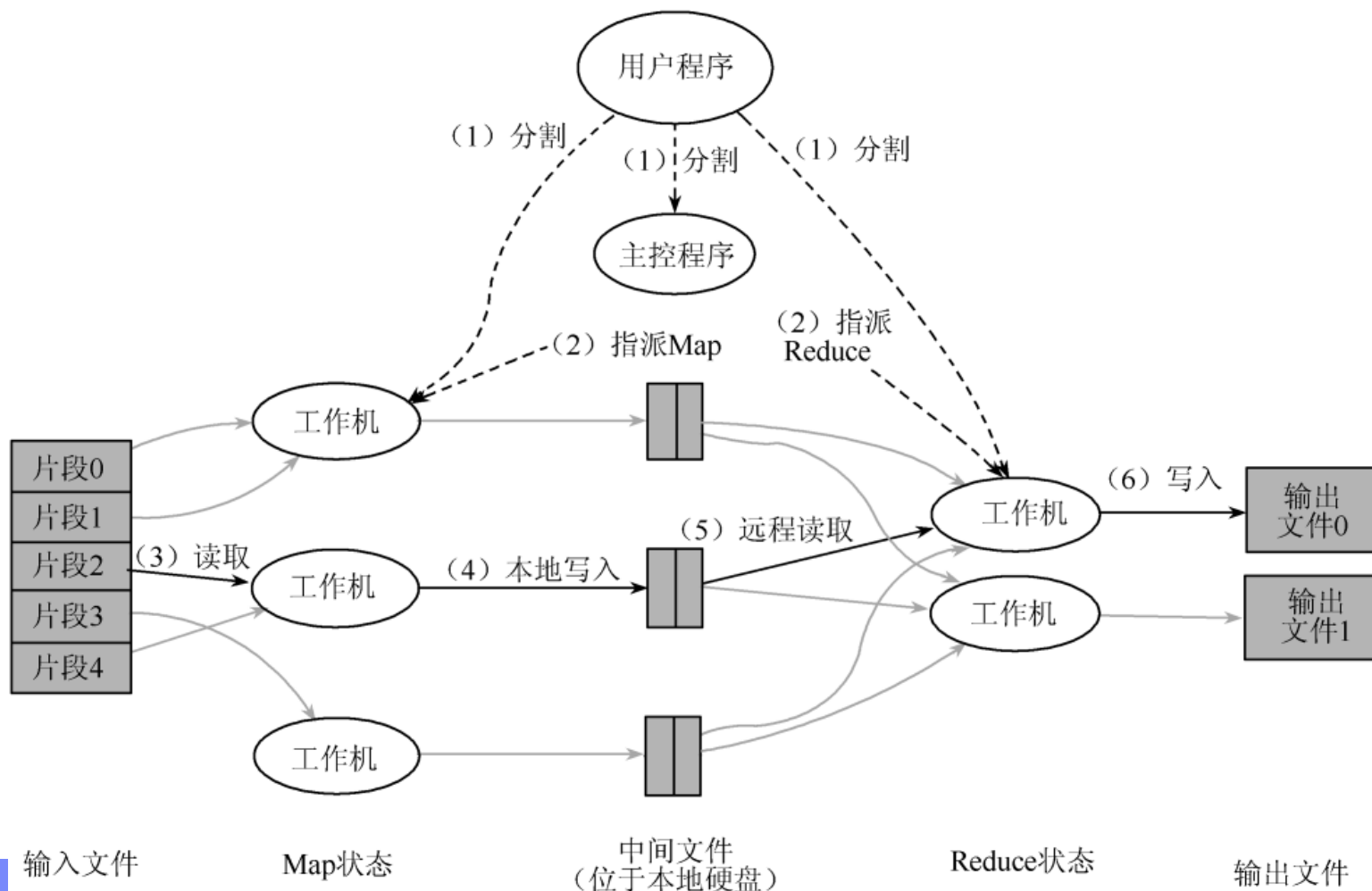
Map: $(in_key, in_value) \rightarrow \{(key_j, value_j) \mid j = 1 \dots k\}$

Reduce: $(key, [value_1, \dots, value_m]) \rightarrow (key, final_value)$



Google云计算关键技术

MapReduce处理过程



Google云计算关键技术

■ MapReduce示例

– 单词计数问题

输入数据:

文件所包含的信息

```
Hello World Bye World  
Hello Hadoop Bye Hadoop  
Bye Hadoop Hello Hadoop
```

MapReduce

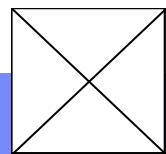
输出数据:

单词所出现的频率

```
Hello: 3  
World: 2  
Bye: 3  
Hadoop: 4
```

– MapReduce方法

```
Map(K,V){  
  For each word w in V  
    Collect(w , 1);  
}  
Reduce(K,V[ ]){  
  int count = 0;  
  For each v in V  
    count += v;  
  Collect(K , count);  
}
```



Google云计算关键技术

■ MapReduce示例

– 单词计数问题

输入数据:

文件所包含的信息

Hello World Bye World
Hello Hadoop Bye Hadoop
Bye Hadoop Hello Hadoop

MapReduce

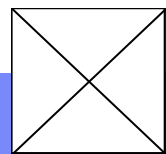
输出数据:

单词所出现的频率

Hello: 3
World: 2
Bye: 3
Hadoop: 4

– MapReduce方法

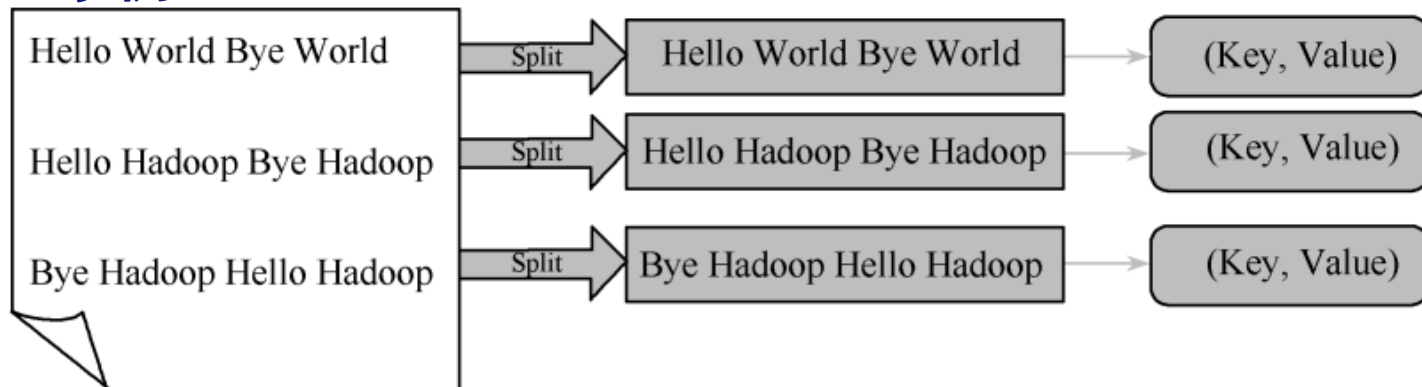
```
Map(K,V){  
  For each word w in V  
    Collect(w , 1);  
}  
Reduce(K,V[ ]){  
  int count = 0;  
  For each v in V  
    count += v;  
  Collect(K , count);  
}
```



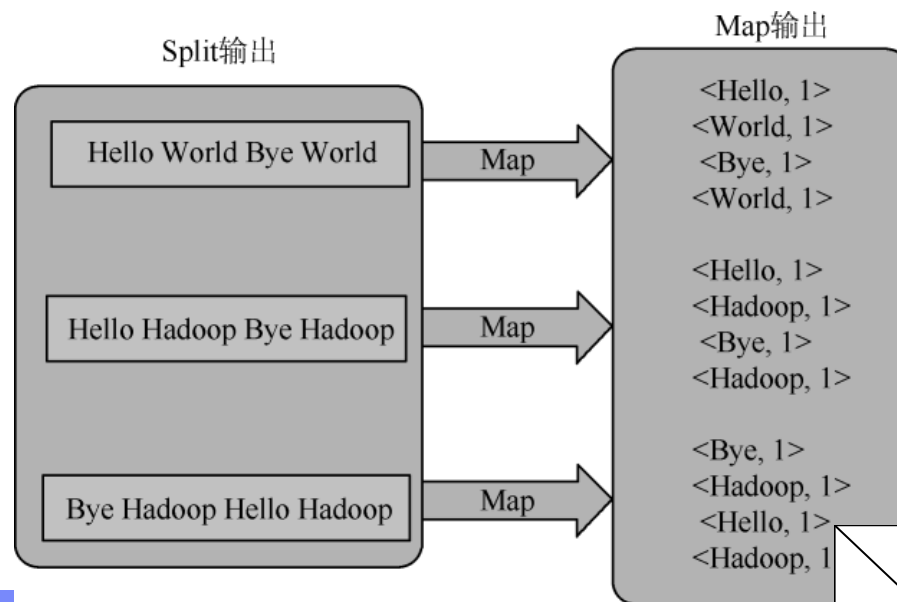
Google云计算关键技术

MapReduce示例

分割



利用用户定义的Map进行处理



Google云计算关键技术

■ MapReduce示例

– 系统自动完成的内部的Fold过程

Map输出

```
<Hello, 1>
<World, 1>
<Bye, 1>
<World, 1>

<Hello, 1>
<Hadoop, 1>
<Bye, 1>
<Hadoop, 1>

<Bye, 1>
<Hadoop, 1>
<Hello, 1>
<Hadoop, 1>
```

Fold输出

```
<Hello, 1>
<Hello, 1>
<Hello, 1>

<World, 1>
<World, 1>

<Bye, 1>
<Bye, 1>
<Bye, 1>

<Hadoop, 1>
<Hadoop, 1>
<Hadoop, 1>
<Hadoop, 1>
```

Flod

– 用户定义的Reduce步骤

Fold输出

```
<Hello, 1>
<Hello, 1>
<Hello, 1>

<World, 1>
<World, 1>

<Bye, 1>
<Bye, 1>
<Bye, 1>

<Hadoop, 1>
<Hadoop, 1>
<Hadoop, 1>
<Hadoop, 1>
```

Reduce输出

```
<Hello, 3>
<World, 2>
<Bye, 3>
<Hadoop, 4>
```

Reduce

Google云计算关键技术

■ 分布式锁服务Chubby

- 提供粗粒度锁服务的一个文件系统,基于松耦合分布式系统,解决了分布的一致性问题。
- 本质上就是一个分布式的、存储大量小文件的文件系统,每一个文件就代表了一个锁,用户通过打开、关闭和读取文件,获取共享(Shared)锁或独占(Exclusive)锁。

■ 分布式结构化数据表Bigtable

- 基于GFS 和Chubby 的分布式存储系统
- 海量结构化和半结构化数据

