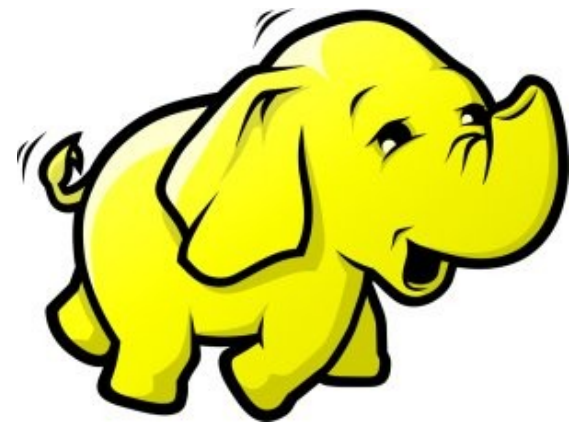




# 淺談海量資料的趨勢、挑戰與因應對策

Big Data : the Trends, Challenges and Solutions

**Jazz Wang**  
**Yao-Tsung Wang**  
**jazz@nchc.org.tw**



# Agenda 演講大綱

**What is Big Data ?** 何謂海量資料

**Why should we care?** 為何需要關切

**When to deploy it ?** 何時導入技術

**How to handle it ?** 三大因應策略

**Who is key player ?** 誰是成功關鍵

# WHAT



## What is Big Data ?

## 何謂海量資料

趨勢

Trends

定義

Definitions

挑戰：管理維度

The Six Dimensions

# Trends .... It's all about **Buzzwords** ..... 「趨勢」亦或「流行語」？ Web 3.0, Cloud Computing, Social Network, Big Data, ....

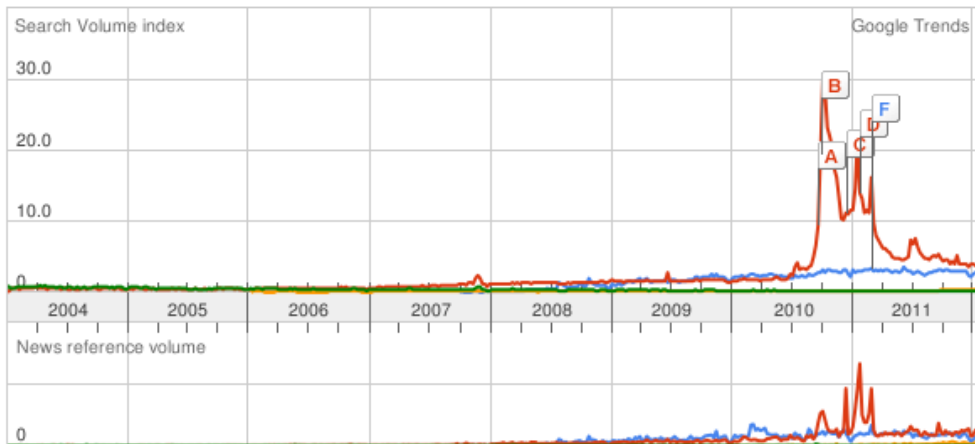
Google Trends  Se

Tip: Use commas to compare multiple search terms.

Searches [Websites](#)

- Scale is based on the average worldwide traffic of **cloud computing** in all years. [Learn more](#)
- An improvement to our geographical assignment was applied retroactively from 1/1/2011. [Learn more](#)

cloud computing 1.00 social network 2.40 big data 0.20  
semantic web 0.40



語意網 ( Semantic Web ) 從 2001 年開始制定標準後，逐漸下滑。而同義詞 Web 3.0 也呈現相似趨勢。海量資料 ( Big Data ) 與其關鍵技術 Hadoop，則仍在上揚中。

A  
B

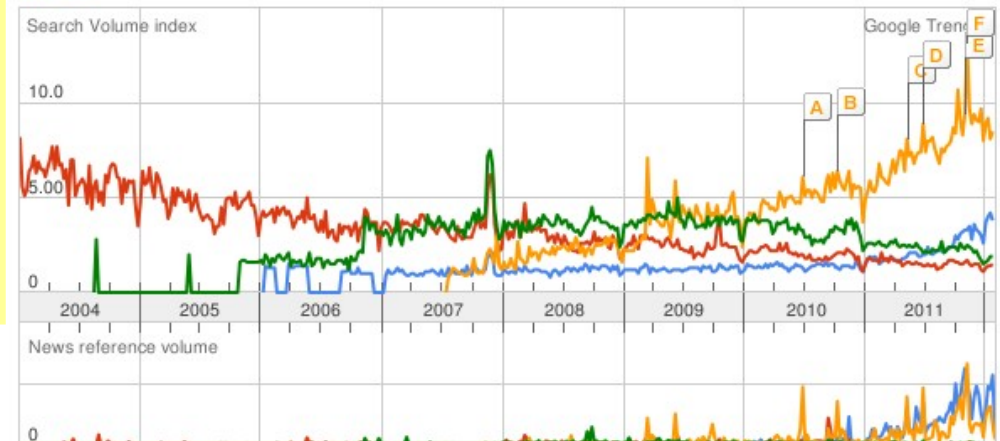
Google Trends  Se

Tip: Use commas to compare multiple search terms.

Searches [Websites](#)

- Scale is based on the average worldwide traffic of **big data** in all years. [Learn more](#)
- An improvement to our geographical assignment was applied retroactively from 1/1/2011. [Learn more](#)

big data 1.00 semantic web 3.30 hadoop 2.50  
web 3.0 2.40



A  
B  
C  
D  
E  
F

整體而言，雲端運算 ( Cloud Computing ) 與社交網路 ( Social Network ) 呈現上揚。且社交網路比雲端運算還引人注目。

# Trends of Market Needs 市場需求趨勢

美國軟體就業市場分析，根據 indeed 與 simply hired 兩間公司的趨勢觀察，都得到一樣的結果：

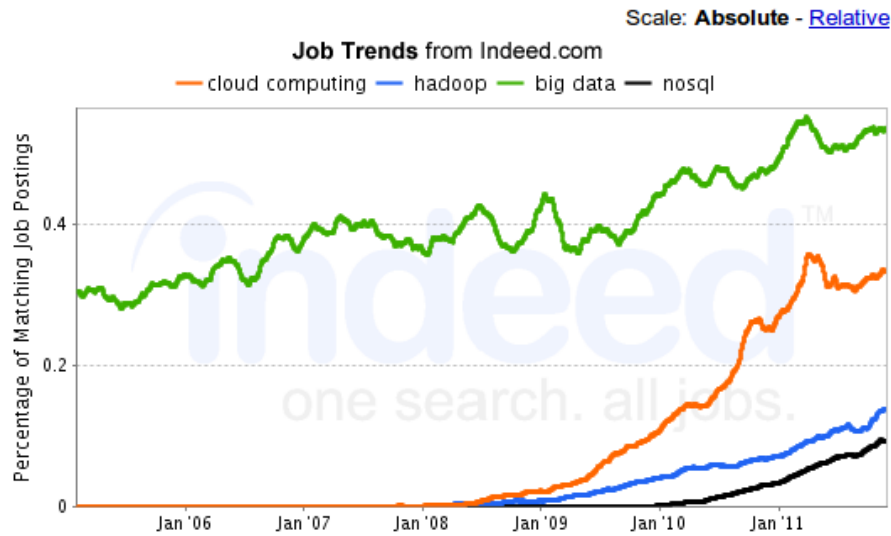
Big Data > Cloud Computing > Hadoop > NoSQL

To

CIO technologies	Ranking of technologies CIOs selected as one of their top 3 priorities in 2012			
Ranking	2012	2011	2010	2009
Analytics and business intelligence	1	5	5	1
Mobile technologies	2	3	6	12
Cloud computing (SaaS, IaaS, PaaS)	3	1	2	16
Collaboration technologies (workflow)	4	8	11	5
Virtualization	5	2	1	3
Legacy modernization	6	7	15	4
IT management	7	4	10	*
Customer relationship management	8	18	*	*
ERP applications	9	13	14	2
Security	10	12	9	8
Social media/Web 2.0	11	10	3	15

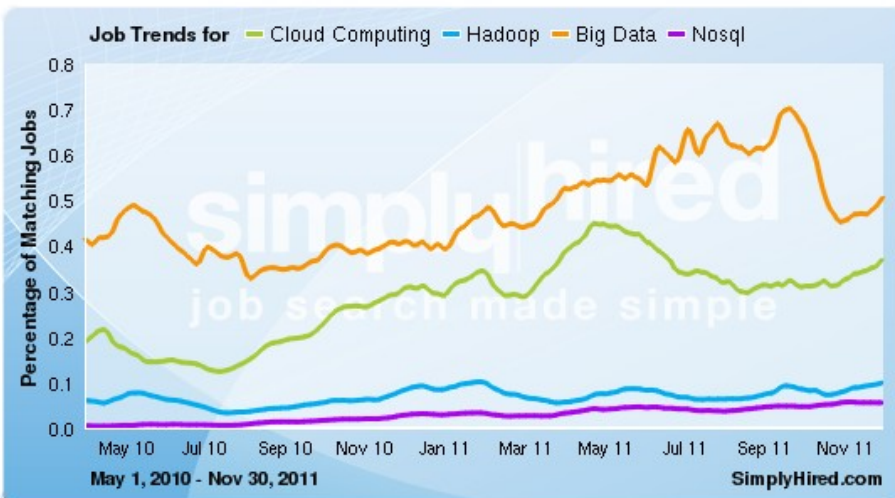
Gartner CIO Agenda 2012 前三名：  
 [1] Business Intelligence (Big Data)  
 [2] Mobile technology  
 [3] Cloud Computing

## cloud computing, hadoop, big data, nosql Job Trends



Indeed.com searches millions of jobs from thousands of job sites. This job trends graph shows the percentage of jobs we find that contain your search terms.

Find [Cloud Computing jobs](#), [Hadoop jobs](#), [Big Data jobs](#), [Nosql jobs](#)

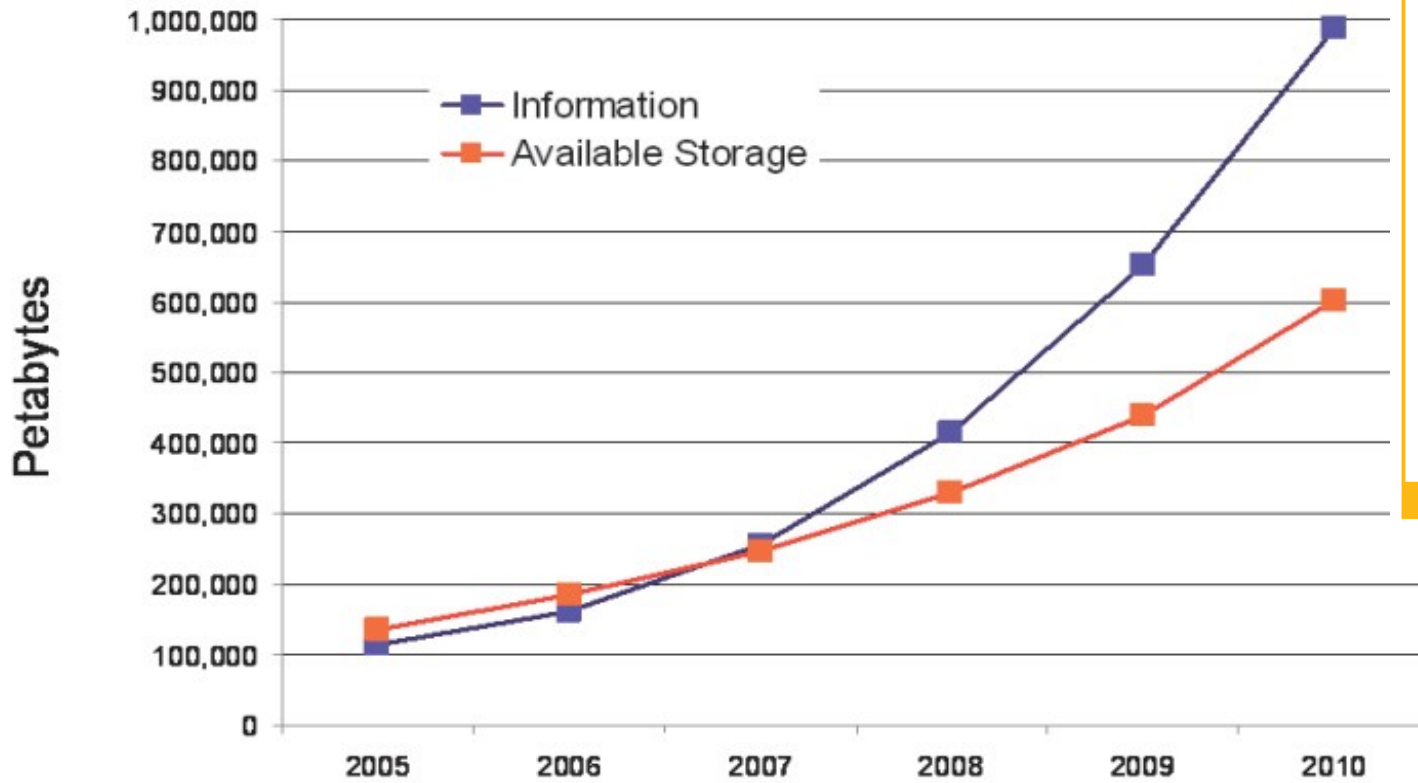


# How BIG? 讓我們先來認識一下容量單位

Bit (b)	1 or 0
Byte (B)	8 bits
Kilobyte (KB)	1,000 bytes
Megabyte (MB)	1,000 KB
Gigabyte (GB)	1,000 MB
Terabyte (TB)	1,000, GB
Petabyte (PB)	1,000 TB
Exabyte (EB)	1,000 PB
Zettabyte (ZB)	1,000 EB

# Data Explosion!! 始於 2007 的「資料大爆炸」時代

## Information Versus Available Storage

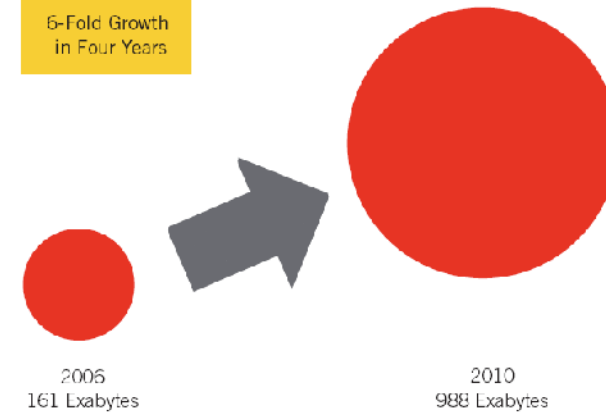


Source: IDC, 2007

Figure 1

### Information Created, Captured and Replicated

6-Fold Growth  
in Four Years



Source: IDC, 2007

2007 年，IDC 預估  
2010 年會成長**六倍**！  
(相較 2006 年)

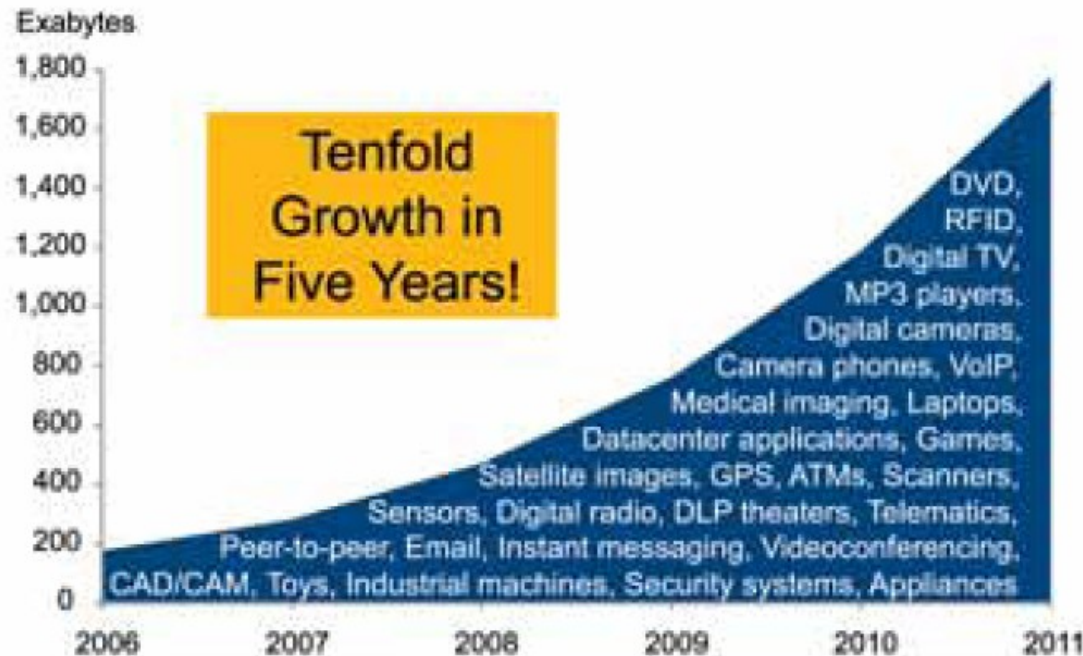
2006 161 EB  
2010 988 EB (預測)

出處：The Expanding Digital Universe,  
A Forecast of Worldwide Information Growth Through 2010,  
March 2007, An IDC White Paper - sponsored by EMC  
<http://www.emc.com/collateral/analyst-reports/expanding-digital-idc-white-paper.pdf>

# Data Explosion!! 始於 2007 的「資料大爆炸」時代

Figure 1

Digital Information Created, Captured, Replicated Worldwide



Source: IDC, 2008

2009 年，IDC 預估  
2011 年會成長**十倍**！  
(相較 2006 年)

2006	161	EB
2007	281	EB
2010	988	EB (預測)
2011	1773	EB (預測)

出處：[The Diverse and Exploding Digital Universe, An Updated Forecast of Worldwide Information Growth Through 2011](#)  
[March 2008](#), An IDC White Paper - [sponsored by EMC](#)  
<http://www.emc.com/collateral/analyst-reports/diverse-exploding-digital-universe.pdf>



# Data expanded 2x each year !! 每年約略兩倍



追蹤歷年的 IDC 數據：

2006 161 EB

2007 281 EB

2008 487 EB

2009 800 EB (0.8 ZB)

2010 988 EB (預測)

2010 1200 EB (1.2 ZB)

2011 1773 EB (預測)

2011 1800 EB (1.8 ZB)

景氣差而成長趨緩？  
或受新技術抑制？

出處：[Extracting Value from Chaos](#),  
June 2011, An IDC White Paper - sponsored by EMC

<http://www.emc.com/collateral/about/news/idc-emc-digital-universe-2011-infographic.pdf>

# What is Big Data?! 何謂『海量資料』？

海量資料泛指資料大小已無法用一般軟體擷取、管理與處理；  
單一資料集大小介於數十 TB 至數 PB 的資料。

'Big Data' = few dozen TeraBytes to PetaBytes in single data set.

## Definition

[edit]

Big data is a term applied to data sets whose size is beyond the ability of commonly used software tools to capture, manage, and process the data within a tolerable elapsed time. Big data sizes are a constantly moving target currently ranging from a few dozen terabytes to many petabytes of data in a single data set.

In a 2001 research report<sup>[14]</sup> and related conference presentations, then META Group (now Gartner) analyst, Doug Laney, defined data growth challenges (and opportunities) as being three-dimensional, i.e. increasing volume (amount of data), velocity (speed of data in/out), and variety (range of data types, sources). Gartner continues to use this model for describing big data.<sup>[15]</sup>

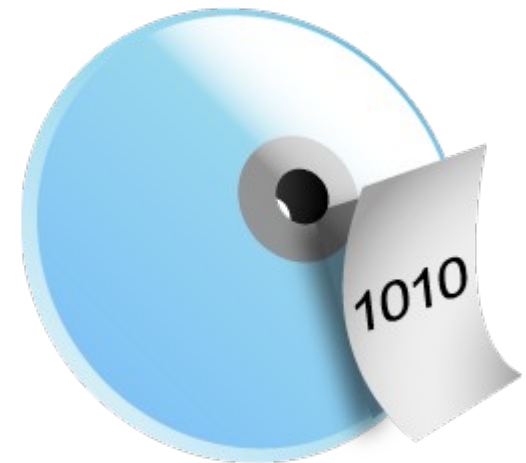
出處：[http://en.wikipedia.org/wiki/Big\\_data](http://en.wikipedia.org/wiki/Big_data)



多個檔案，容量 100TB



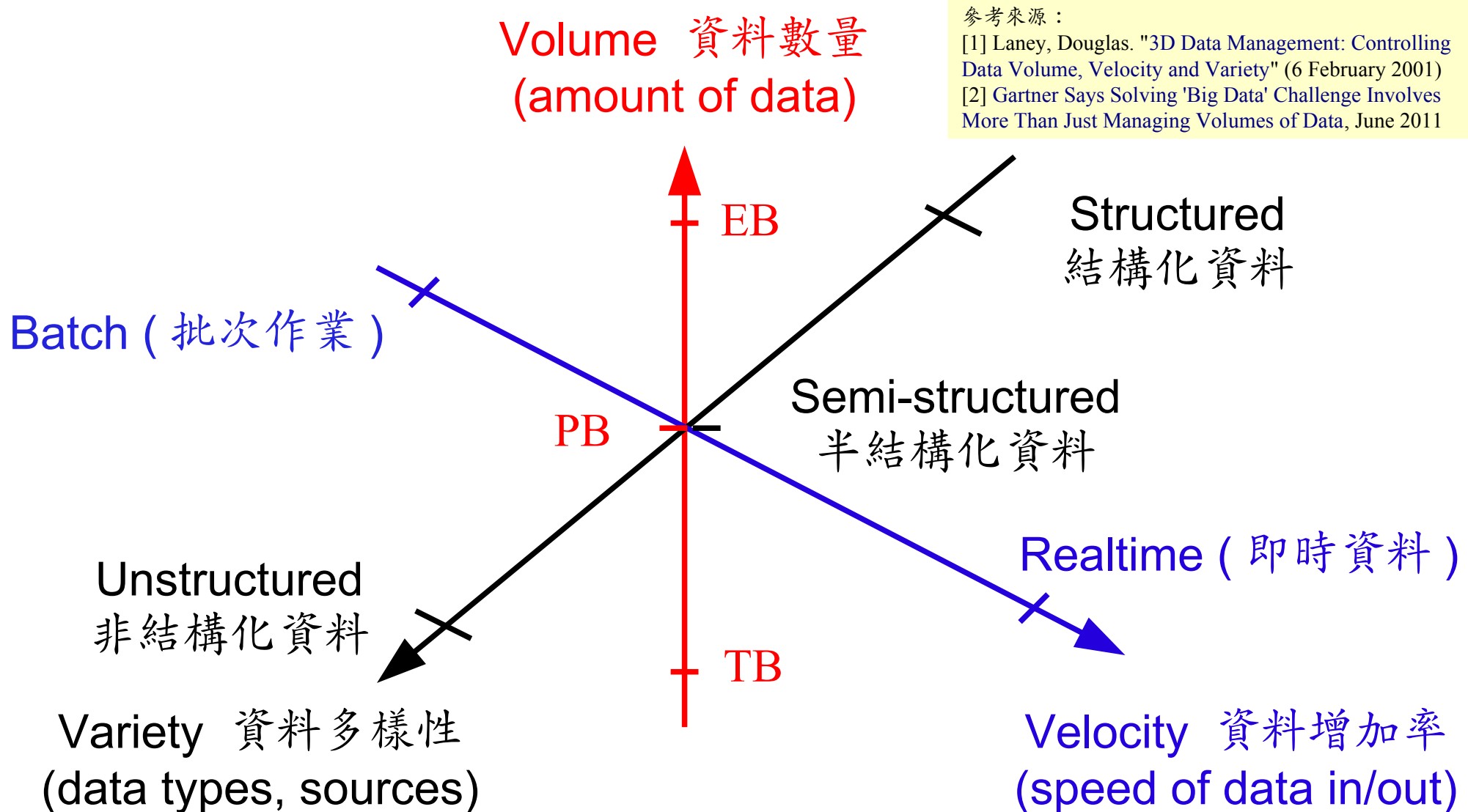
一個資料庫，容量 100TB



一個檔案，容量 100TB

# Gartner Big Data Model? 海量資料的模型?

海量資料的挑戰在於如何管理「數量」、「增加率」與「多樣性」



# Six Dimensions of Big Data? 六個維度?



# 12D of Information Management? 12 個維度?



Source: Gartner (March 2011), 'Big Data' Is Only the Beginning of Extreme Information Management, 7 April 2011, <http://www.gartner.com/id=1622715>

# Agenda 演講大綱

What is Big Data ?

何謂海量資料

Why should we care?

為何需要關切

資料 Data

知識 Knowledge

智慧 Wisdom

WHY



花精靈-小葵

# Why we call it “SMART” !!

智慧打哪兒來？！

**Smart Phone**

智慧手機

**Smart Car**

智慧車輛

**Smart Grid**

智慧電網

**SMART**

哪裡長  
智慧了？

**Smart City**

智慧城市

**Smart Home**

智慧家庭

**Smart Meter**

智慧電錶

資料

Data

知識

Knowledge

智慧

Wisdom

# Can Machine understand You? 讓機器更懂你?

iPhone

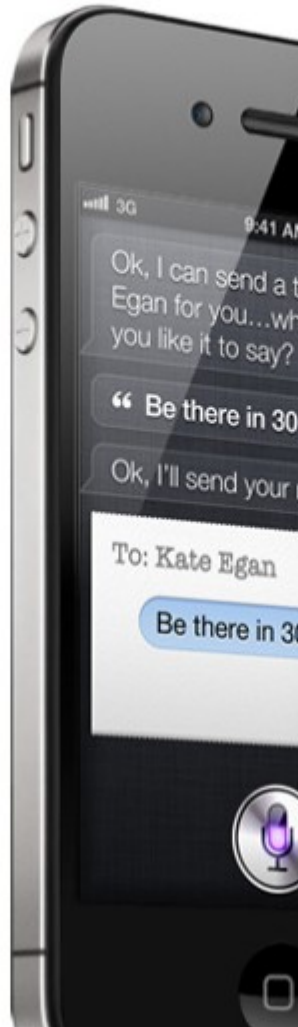
Features Built-in Apps



Siri. Beta

Your wish is its command.

Siri on iPhone 4S lets you use your voice to send messages, schedule meetings, place phone calls, and more. Ask Siri to do things just by talking the way you talk. Siri understands what you say, knows what you mean, and even talks back. Siri is so easy to use and does so much, you'll keep finding more and more ways to use it.



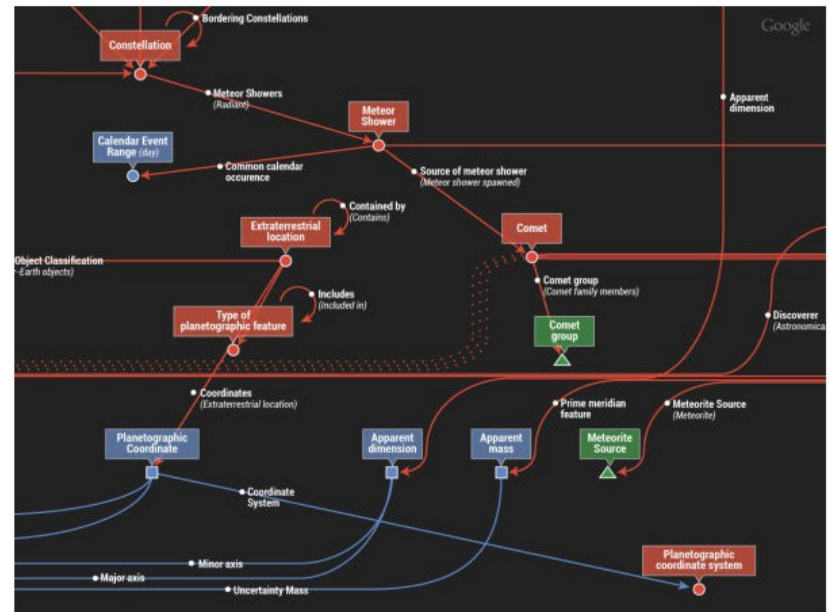
## Google將發展「人工智慧」 永久改變搜尋引擎

2012年02月15日 00:11

點評: 超級阿斯拉, 衝啊! (阿斯拉: 好的, 華人!)

記者黃郁棋 / 綜合報導

每個人都在猜, 下一波網路革命是什麼? 每個人都在猜, 未來的世界會如何運作? Google的資深副總Amit Singhai透露了一點訊息。「Google正努力從『單字』層面進展到『意義』層面, 未來搜尋引擎提供的不只是關鍵字搜尋, 搜尋引擎甚至會『明白』你到底要什麼。」

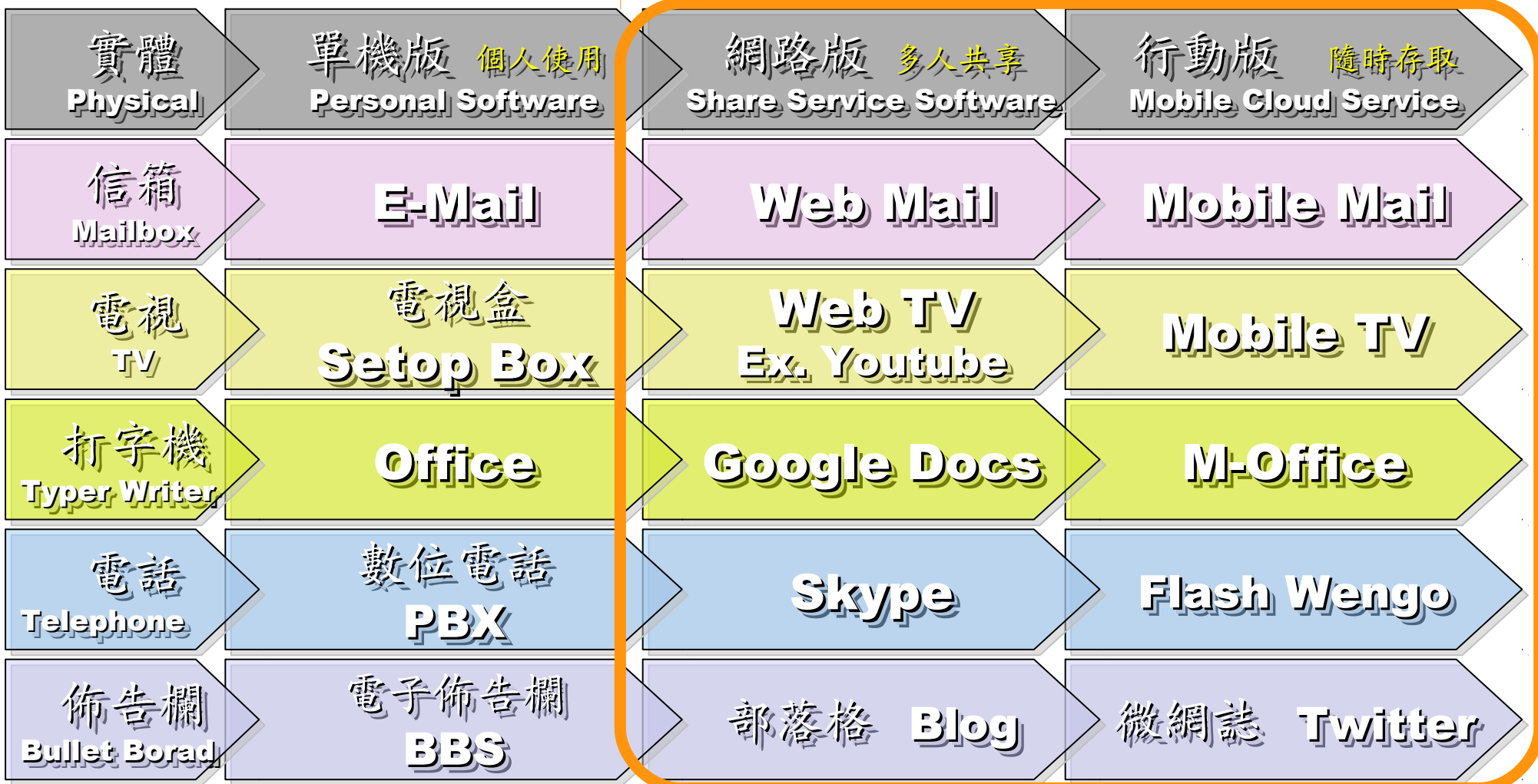


▲ Google未來將會朝「人工智慧」前進。(圖 / 取自mashable.com)



# Evolution of Software / Service

## 軟體演化勢必走向『智能化』



# The wisdom of Clouds (Crowds)

雲端序曲：雲端的智慧始終來自於群眾的智慧

2006年8月9日

Google 執行長施密特 ( Eric Schmidt ) 於SES'06會議中首次使用「雲端運算 ( Cloud Computing ) 」來形容無所不在的網路服務

2006年8月24日

Amazon 以 Elastic Compute Cloud 命名其虛擬運算資源服務



# Data is the source of Wisdom !!

## 用雲掌握資料，加以分析，形成智能給端用



# 雲

資料中心  
提供服務

## 雲端設計新思維：端的智能來自於雲的服務

## Devices share the wisdom of Cloud

# 端



各類裝置  
存取服務

# Agenda 演講大綱

What is Big Data ? 何謂海量資料

Why should we care? 為何需要關切

**When to deploy it ?** 何時導入技術

基礎建設 IaaS

分析平台 PaaS

智慧服務 SaaS

## WHEN



花精靈-小鬱

# National Definition of Cloud Computing

## 美國國家標準局 NIST 給雲端運算所下的定義

### 5 Characteristics

五大基礎特徵

### 4 Deployment Models

四個佈署模型

### 3 Service Models

三個服務模式

#### 1. On-demand self-service.

隨需自助服務

#### 2. Broad network access

隨時隨地用任何網路裝置存取

#### 3. Resource pooling

多人共享資源池

#### 4. Rapid elasticity

快速重新佈署靈活度

#### 5. Measured Service

可被監控與量測的服務

# 4 Deployment Models of Cloud Computing

## 雲端運算的四種佈署模型

Public Cloud

公用雲端



Target Market

is **S.M.B.**

主要客戶為  
中小企業

**Dynamic Resource Provisioning  
between public and private cloud**

私有雲端動態根據計算需求  
調用公用雲端的資源

Hybrid  
Cloud

以大型企業  
為主要客戶

**Enterprise is  
key market**

Community Cloud

社群雲端

Academia 學術為主



私有雲端

Private Cloud

# 3 Service Models of Cloud Computing

## 雲端運算的三種服務模式 (市場區隔)

### IaaS

Infrastructure as a Service

架構即服務

### PaaS

Platform as a Service

平台即服務

### SaaS

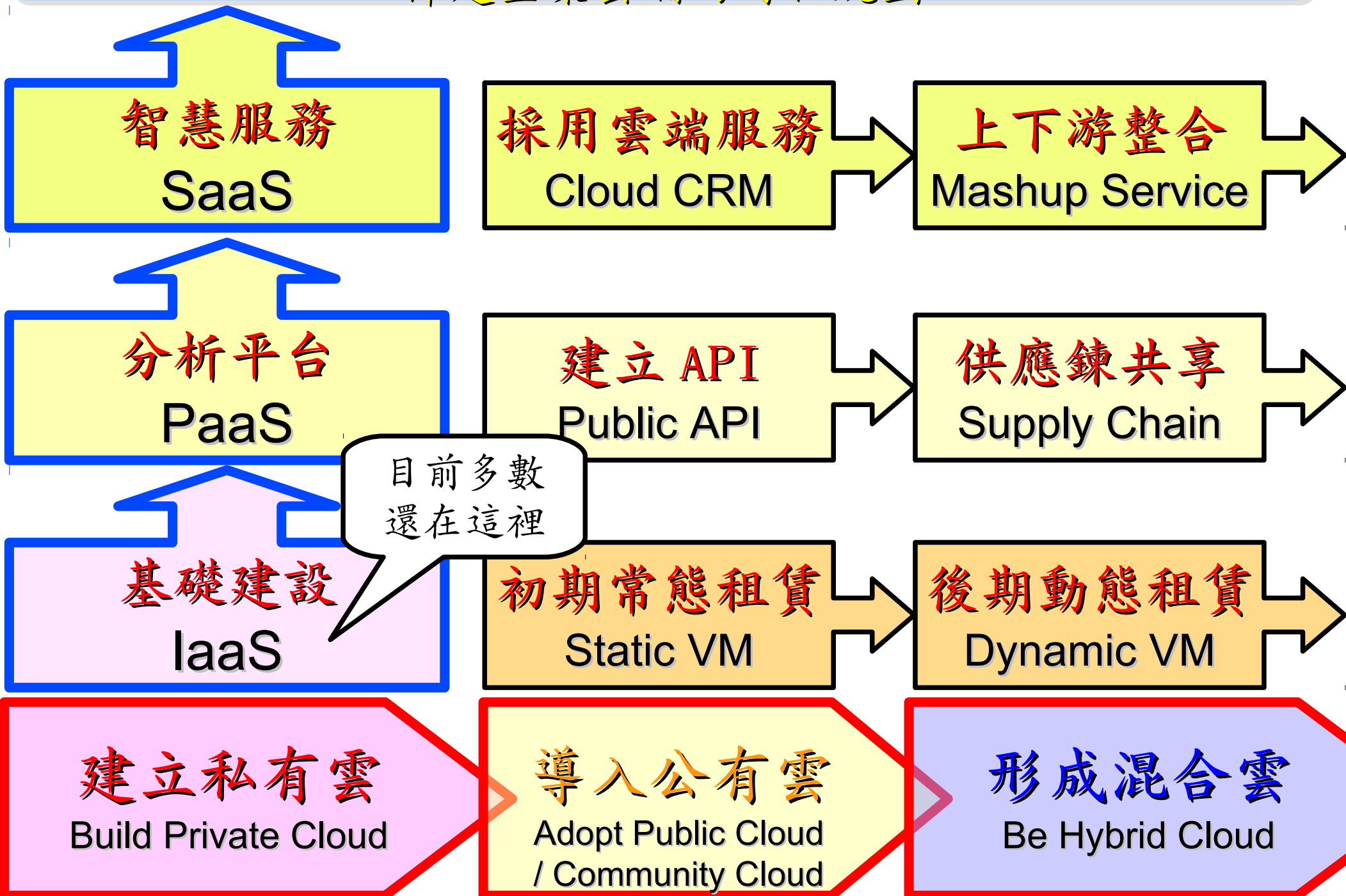
Software as a Service

軟體即服務



# Roadmap to build Your Enterprise Cloud !!

佈建企業雲端的時程規劃





# Agenda 演講大綱

What is Big Data ? 何謂海量資料

Why should we care? 為何需要關切

When to deploy it ? 何時導入技術

**How to handle it ?** 三大因應策略

儲存虛擬化 Dedup.

資料安全 Security

智慧服務 SaaS

## HOW



花精靈-麗兒

# Three Solutions !! 三種服務模式 vs. 三類因應對策

## SaaS

Software as a Service

軟體即服務

## Web 2.0

網頁服務

(A) 提供 API 介面

(B) 分散式資料庫

## PaaS

Platform as a Service

平台即服務

## Data Analysis

資料分析

(A) 資料整合

(B) 資料探勘

## IaaS

Infrastructure as a Service

架構即服務

## Virtualization

虛擬化技術

(A) 儲存虛擬化

(B) 備援與加密

# Agenda 演講大綱

**What is Big Data ?** 何謂海量資料

**Why should we care?** 為何需要關切

**When to deploy it ?** 何時導入技術

**How to handle it ?** 三大因應策略

**Who is key player ?** 誰是成功關鍵



# Data Scientist !! 資料科學家 !!

## Data scientist: The hot new gig in tech

By Michal Lev-Ram, writer September 6, 2011: 5:00 AM ET

Companies that want to make sense of all their bits and bytes are hiring so-called data scientists - if they can find any.



ILLUSTRATION: GAVIN POTENZA

FORTUNE -- The unemployment rate in the U.S. continues to be abysmal (9.1% in July), but the tech world has spawned a new kind of highly skilled, nerdy-cool job that companies are scrambling to fill: data scientist.

會「統計」的人照過來！

財星雜誌 (FORTUNE) 等均報導今年最熱門的職缺是「資料科學家」！

## What is data science?

Data science can be broken down into four essential parts.

### Mining data



Collecting and formatting the information

### Statistics



Information analysis

### Interpret



Representation or visualization in the form of presentations, infographics, graphs or charts

### Leverage



Implications of the data, application of the data, interaction using the data and predictions formed from studying it



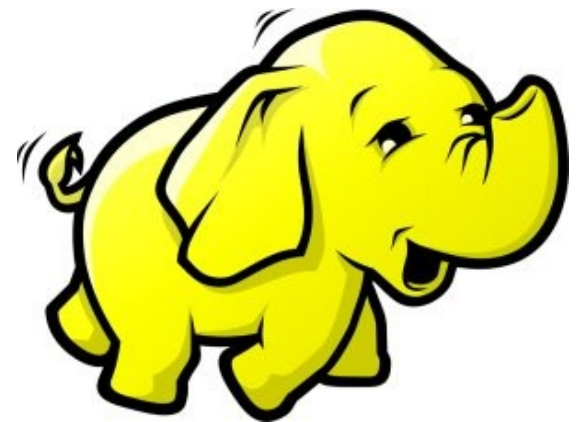
# 處理海量資料的資訊架構與關鍵技術

Technologies to build IT Stack for Big Data

**Jazz Wang**

**Yao-Tsung Wang**

**[jazz@nchc.org.tw](mailto:jazz@nchc.org.tw)**



# Hot Jobs in Big Data

## 從海量資料的熱門工作談起

**Data Mining**

**資料探勘**

**Data Visualization**

**資料視覺化**

**Data Analysis**

**資料分析**

**Data Manipulation**

**資料操控**

**Data Discovery**

**資料鑑識**

How to Get a Hot Job in Big Data, Dan Tynan, InfoWorld, March 19, 2012  
出處：<http://www.cio.com/article/print/702388>

# Applications of Data Mining

## 資料探勘的應用 - 搜尋引擎

搜尋結果

### 檔案搜尋

網址(D) 搜尋結果


搜尋小幫手

您想要搜尋什麼?

- 圖片、音樂、或視訊(P)
- 文件(文字處理、試算表, 等等)(O)
- 所有檔案和資料夾(L)
- 電腦或人員(C)
- 說明和支援中心裡的資訊(I)

您也可能想要...

- 搜尋網際網路(S)
- 變更喜好(G)



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Date within 1 day of

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Create

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日 (週五)

- (10時53分48秒) Shunfa 楊順發
- (10時53分51秒) Jazz Yao-Tsung
- (10時54分08秒) Shunfa 楊順發
- (10時54分42秒) Jazz Yao-Tsung
- (10時54分49秒) Jazz Yao-Tsung
- (10時54分51秒) Jazz Yao-Tsung
- (10時55分02秒) Shunfa 楊順發
- (10時55分04秒) Shunfa 楊順發
- (10時55分39秒) Jazz Yao-Tsung

3 KiB

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# YAHOO! 奇摩

網頁 | 知識+ | 圖片 | 影片 | 部落格 | 字典 | 新聞 | 購物<sup>BETA</sup>

網頁搜尋

熱門: 第一美腿 12歲父親 嫩模女神 幼稚病 51區 花心星座 解夢 知識: 傷口癢竟是 電鍋料理

2011 資訊月 ONLINE 3G特展搶先看!!

# Applications of Data Visualization

## 資料視覺化的應用 - Infographics

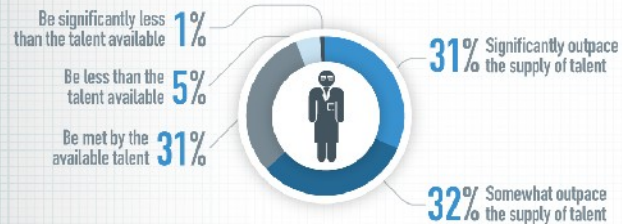
### Data Scientist Study



The explosion in digital data, bandwidth and processing power — combined with new tools for analyzing the data — has sparked massive interest in the emerging field of data science. Organizations of all sizes are turning to people who are capable of translating this trove of data — created by mobile sensors, social media, surveillance, medical imaging, smart grids and the like — into predictive insights that lead to business value. Despite the growing opportunity, demand for data scientists has outpaced supply of talent, and will for the next five years. Who are data science practitioners, what skills do they need, and why are they so different?

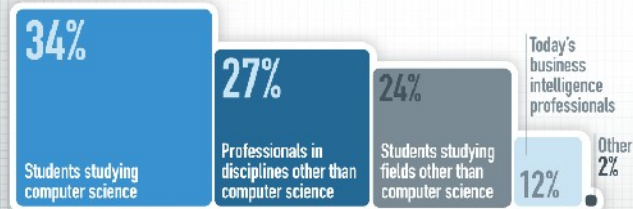
Over 2/3 believe demand for talent will outpace the supply of data scientists

OVER THE NEXT FIVE YEARS, DEMAND FOR DATA SCIENTISTS WILL:



Only 12% see today's BI professional as the best source for new data scientists

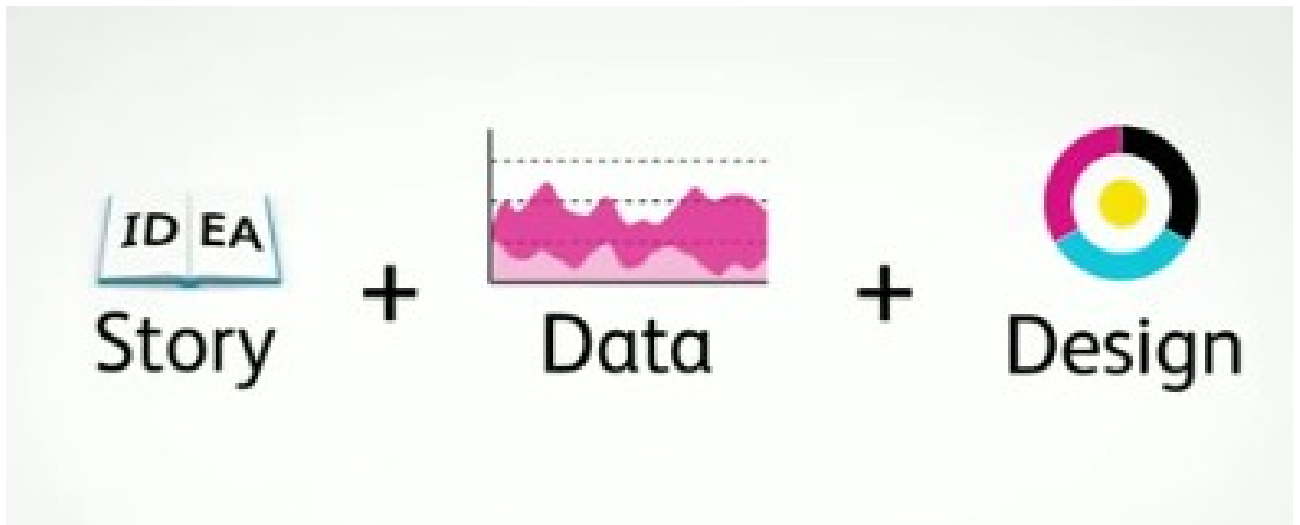
THE BEST SOURCE OF NEW DATA SCIENCE TALENT IS:



DUET TO THE ROUNDING, SOME PERCENTAGES MAY NOT ADD UP TO 100

Lack of training and resources are the biggest obstacle to data science in organizations

THE BIGGEST OBSTACLE TO DATA SCIENCE ADOPTION IN OUR ORGANIZATION IS:



參考來源：未來「夯」職業：資料科學家  
淺談超吸睛的資訊圖表

<http://www.bnext.com.tw/print/article/id/21740>  
<http://www.inside.com.tw/2011/04/13/infographics>



# Applications of Data Analysis

## 資料分析的應用 - 商業智慧 (BI)



# Applications of Data Discovery

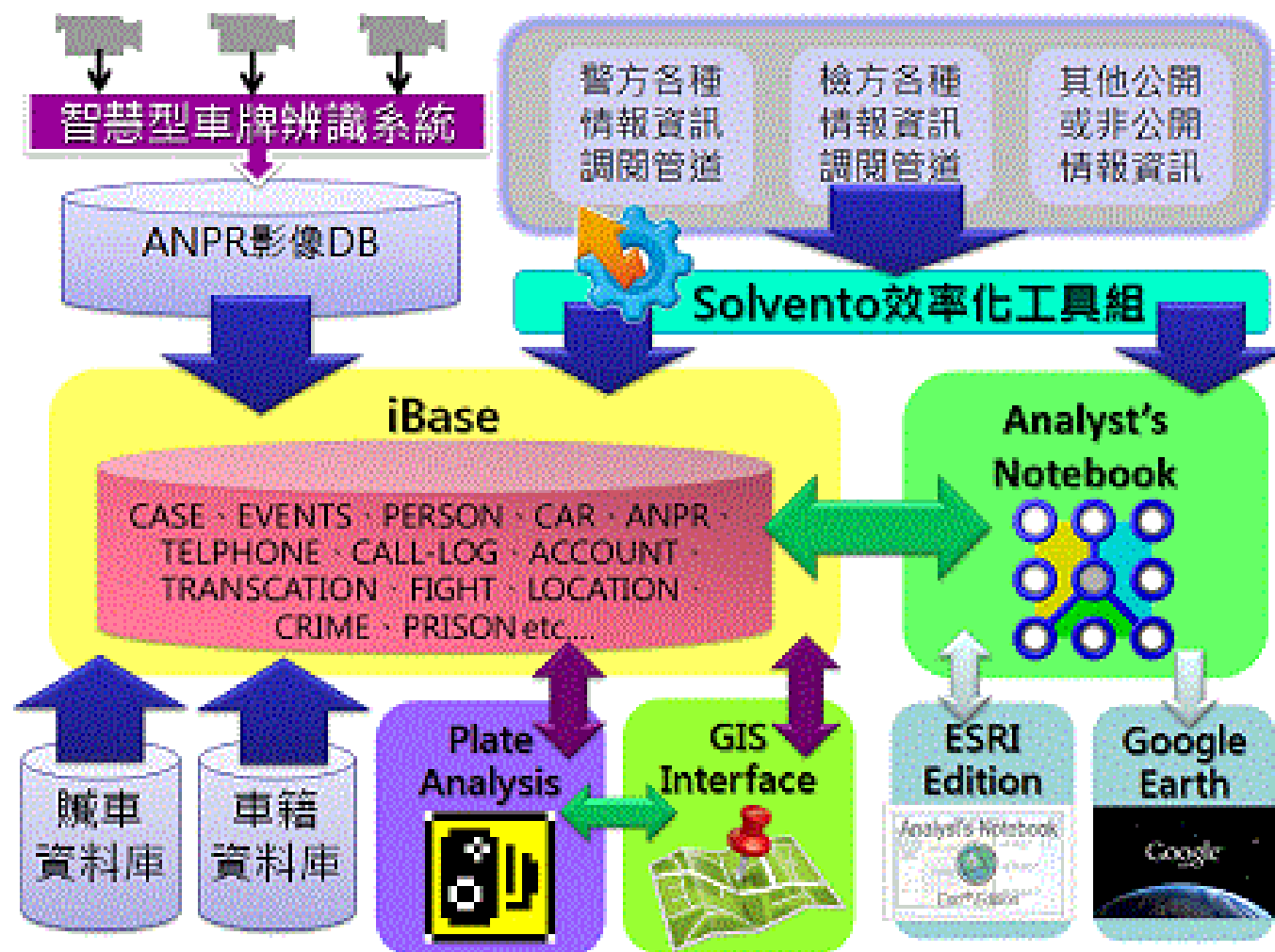
## 數位鑑識 - 資訊與法律的結合

### 電腦鑑識&會計鑑識

[http://www.solventosoft.com/upload/ANPR\\_02s.gif](http://www.solventosoft.com/upload/ANPR_02s.gif)

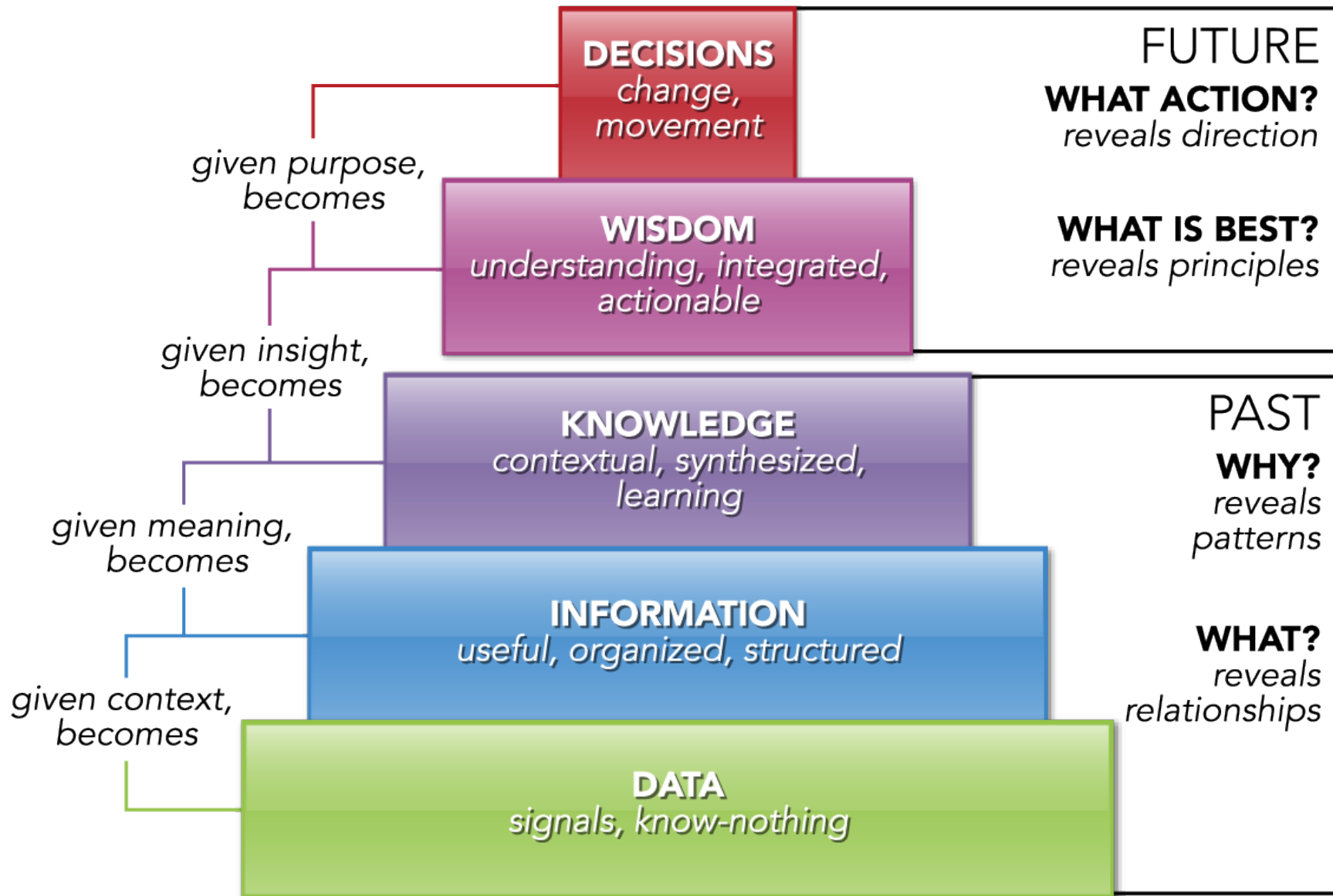


<http://blog.udn.com/kf0630/6018593>



# Data, Information, Knowledge, Wisdom

## 知識管理模型：資料、資訊、知識與智慧



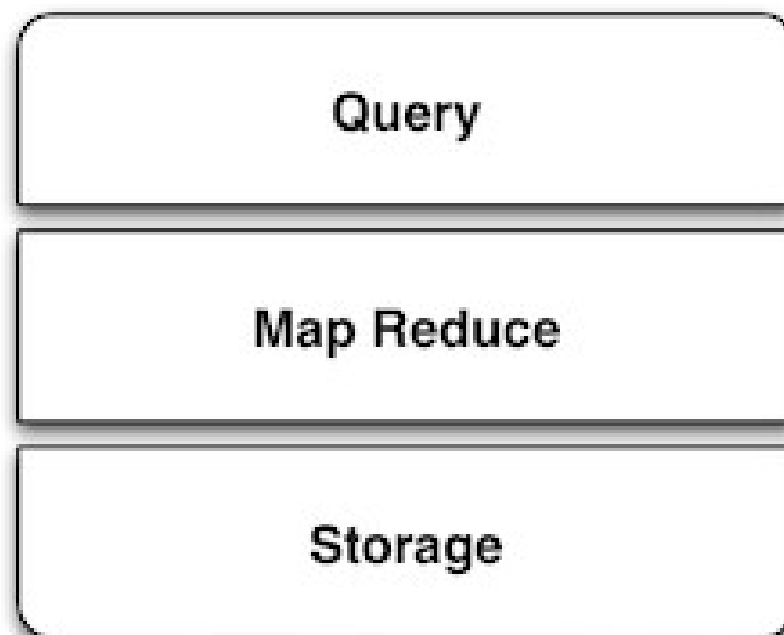
# The SMAQ stack for big data

## 海量資料處理的資訊架構

做網頁相關的人可能聽過 LAMP



未來處理海量資料的人必需知道  
SMAQ (Storage, MapReduce and Query)

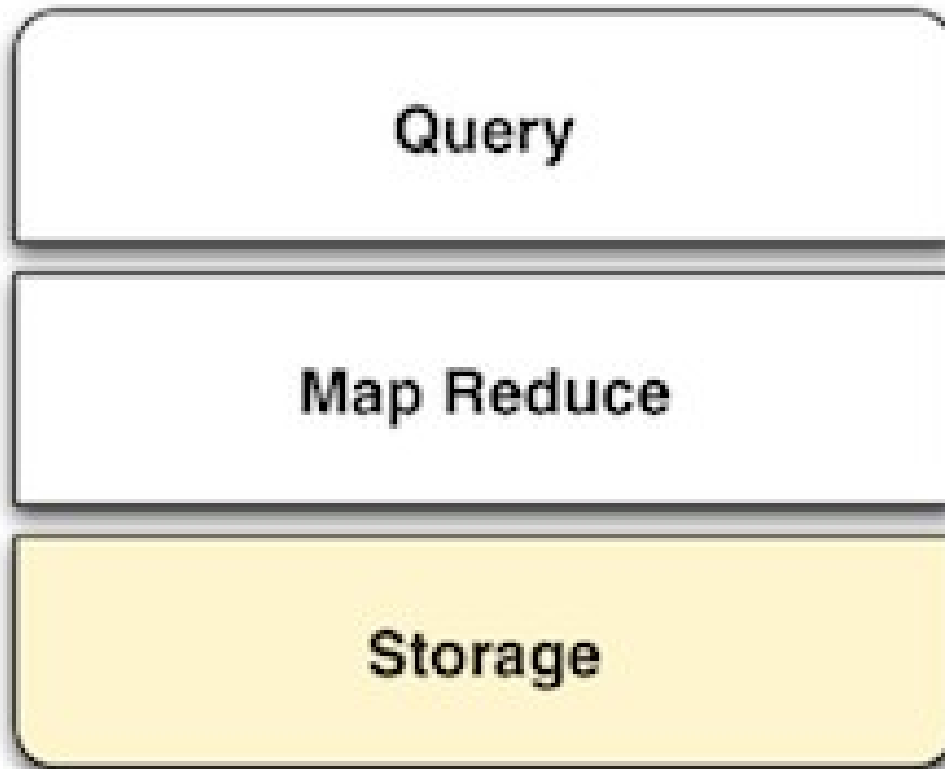


參考來源：The SMAQ stack for big data，Edd Dumbill，22 September 2010，  
<http://radar.oreilly.com/2010/09/the-smaq-stack-for-big-data.html>

圖片來源：<http://smashingweb.ge6.org/wp-content/uploads/2011/10/apache-php-mysql-ubuntu.png> 37

# The SMAQ stack for big data

## 海量資料處理的資訊架構



用來儲存分散、沒有關聯  
的非結構化資料

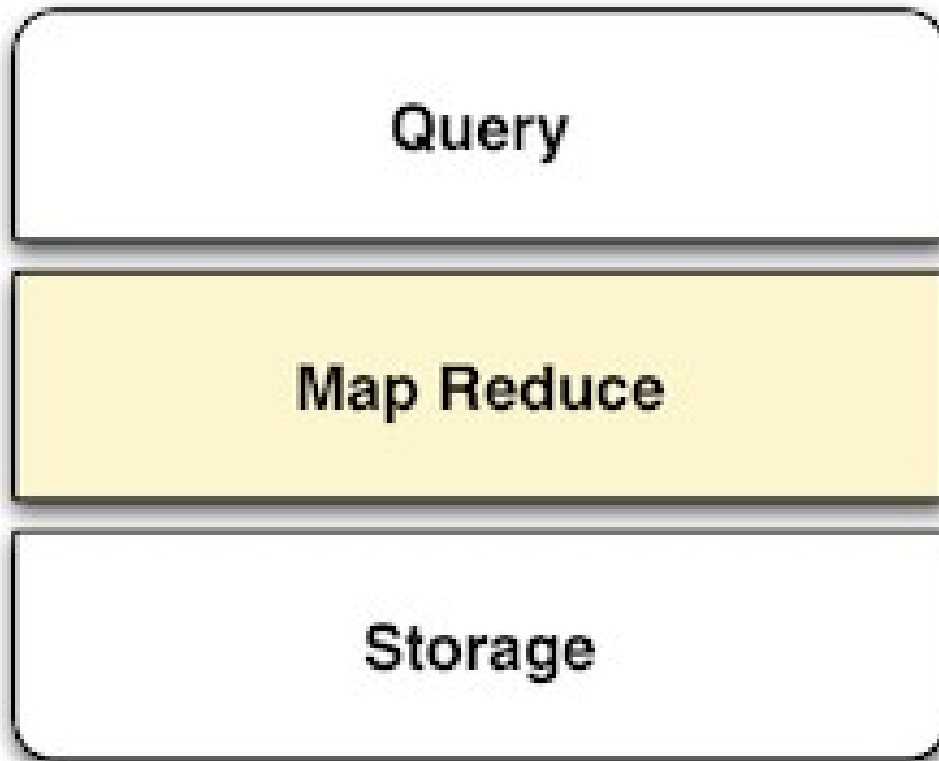
### Key features

- Distributed
- Non-relational or unstructured

# The SMAQ stack for big data

## 海量資料處理的資訊架構

運用批次處理的方式，將  
運算工作平均分散到許多  
的伺服器做運算。

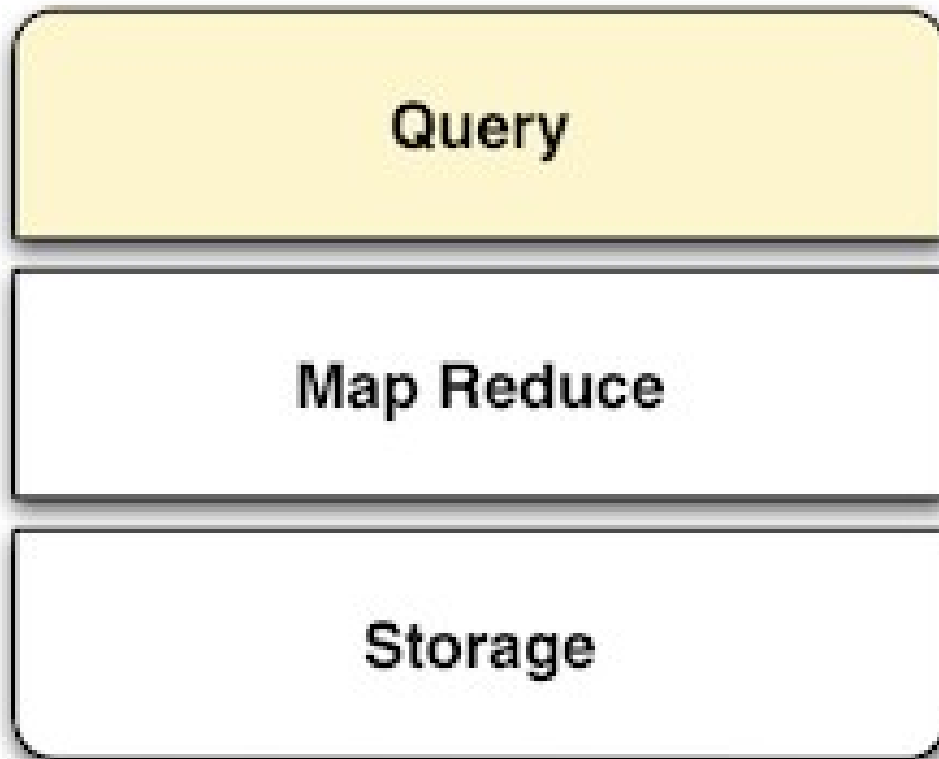


### Key features

- Distributes computation over many servers
- Batch processing model

# The SMAQ stack for big data

## 海量資料處理的資訊架構



### Key features

- Efficient way of defining computation
- Platform for user friendly analytical systems

將算完的結構化資料儲存到可供查詢的資料庫系統

# Three Core Technologies of Google ....

## Google 的三大關鍵技術 .....

- Google 在一些會議分享他們的三大關鍵技術
- Google shared their design of web-search engine
  - SOSP 2003 :
    - “The Google File System”
    - <http://labs.google.com/papers/gfs.html>
  - OSDI 2004 :
    - “MapReduce : Simplified Data Processing on Large Cluster”
    - <http://labs.google.com/papers/mapreduce.html>
  - OSDI 2006 :
    - “Bigtable: A Distributed Storage System for Structured Data”
    - <http://labs.google.com/papers/bigtable-osdi06.pdf>





# Open Source Mapping of Google Core Technologies

## Google 三大關鍵技術對應的自由軟體

### BigTable

A huge key-value datastore

HBase, Hypertable  
Cassandra, ....

### MapReduce

To parallel process data

Hadoop MapReduce API  
Sphere MapReduce API, ...

### Google File System

To store petabytes of data

Hadoop Distributed File System (HDFS)  
Sector Distributed File System

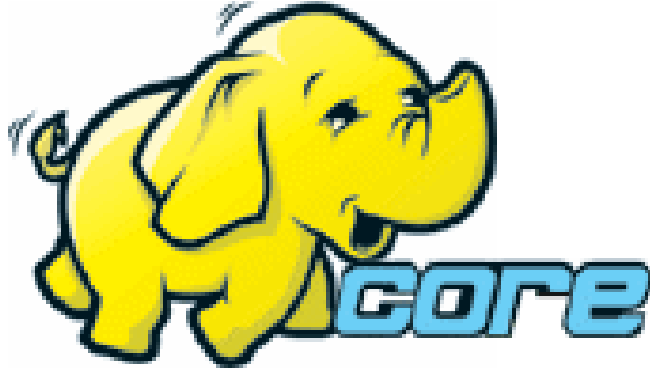
更多不同語言的 MapReduce API 實作：

<http://trac.nchc.org.tw/grid/intertrac/wiki%3Ajazz/09-04-14%23MapReduce>

其他值得觀察的分散式檔案系統：

- IBM GPFS - <http://www-03.ibm.com/systems/software/gpfs/>
- Lustre - <http://www.lustre.org/>
- Ceph - <http://ceph.newdream.net/>

# Hadoop

- <http://hadoop.apache.org>
  - Hadoop 是 Apache Top Level 開發專案
  - **Hadoop is Apache Top Level Project**
  - 目前主要由 Yahoo! 資助、開發與運用
  - **Major sponsor is Yahoo!**
  - 創始者是 Doug Cutting，參考 Google Filesystem
  - **Developed by Doug Cutting, Reference from Google Filesystem**
  - 以 Java 開發，提供 HDFS 與 MapReduce API。
  - **Written by Java, it provides HDFS and MapReduce API**
  - 2006 年使用在 Yahoo 內部服務中
  - **Used in Yahoo since year 2006**
  - 已佈署於上千個節點。
  - **It had been deploy to 4000+ nodes in Yahoo**
  - 處理 Petabyte 等級資料量。
  - **Design to process dataset in Petabyte**
- 
- Facebook、Last.fm  
、Joost are also  
powered by Hadoop**

# Sector / Sphere

- <http://sector.sourceforge.net/>
- 由美國資料探勘中心研發的自由軟體專案。
- **Developed by National Center for Data Mining, USA**
- 採用 C/C++ 語言撰寫，因此效能較 Hadoop 更好。
- **Written by C/C++, so performance is better than Hadoop**
- 提供「類似」Google File System 與 MapReduce 的機制
- **Provide file system similar to Google File System and MapReduce API**
- 基於UDT高效率網路協定來加速資料傳輸效率
- **Based on UDT which enhance the network performance**
- Open Cloud Testbed有提供測試環境，並開發Ma1Stone效能評比軟體
- **Open Cloud Consortium provide Open Cloud Testbed and develop Ma1Stone toolkit for benchmark**

**Sector-Sphere**

National Center for Data Mining  
University of Illinois at Chicago

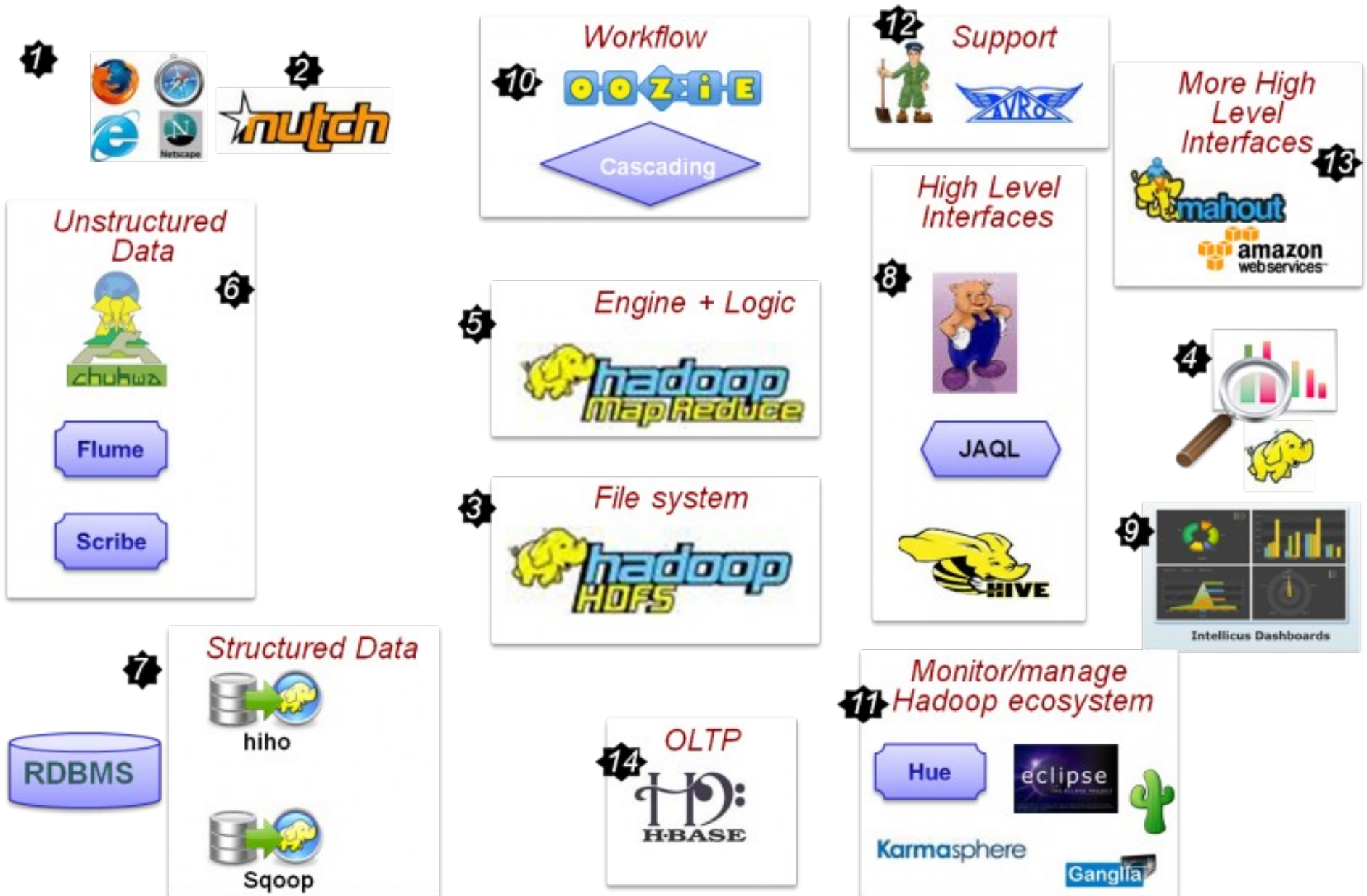


Open Data Group

<http://www.opendatagroup.com/>

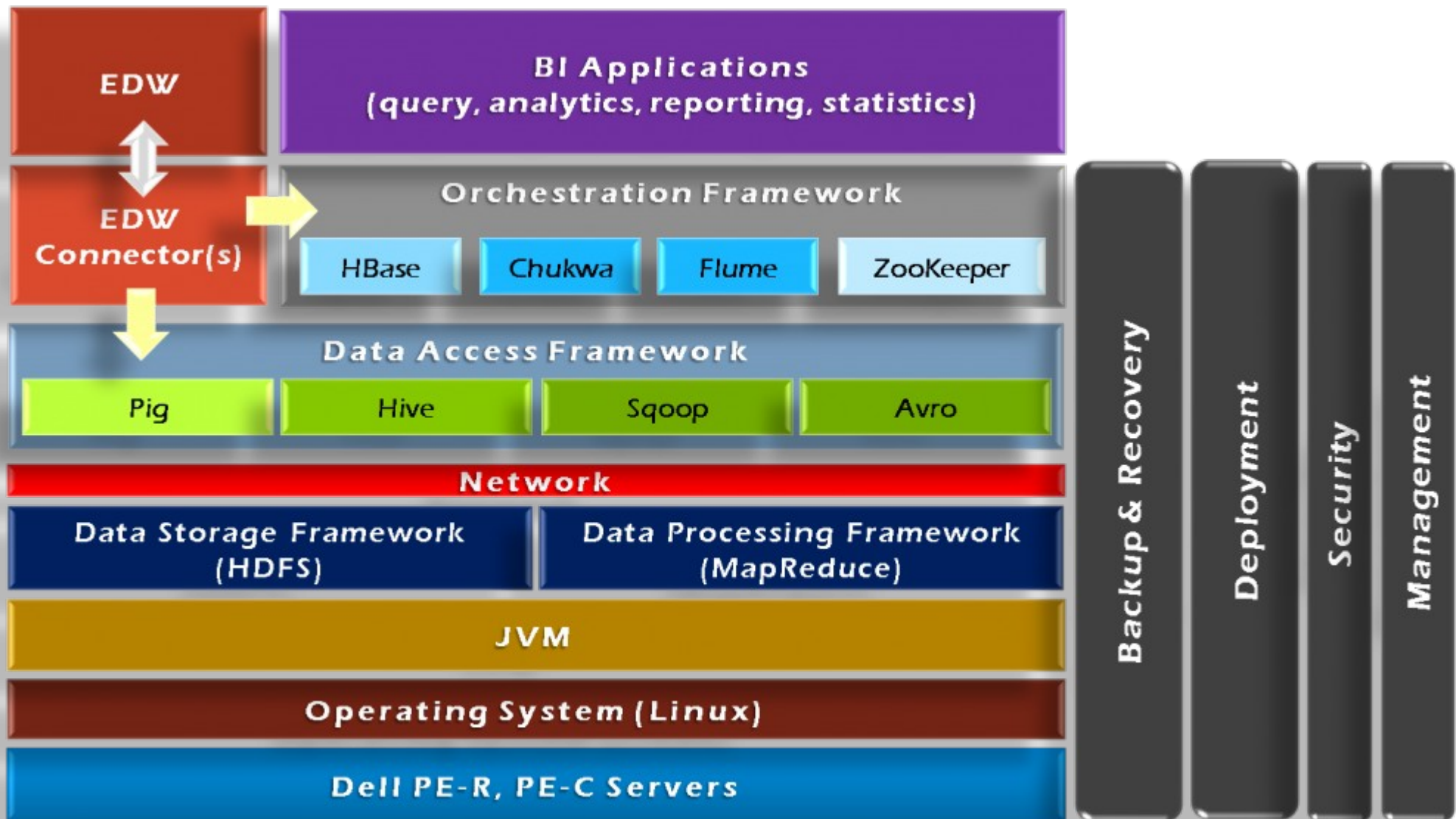
# Why we choice Hadoop? Good Ecosystem!

豐富的生態系建構出處理海量資料的工具庫



# BI and EDW build on Hadoop Ecosystem

運用 Hadoop 生態系搭建資料倉儲與商業智慧分析



# Build your own search engine, too

您也能用 **Hadoop** 搭建自己的搜尋引擎

Web UI ( Crawlzilla Website + Search Engine)

JSP + Servlet + JavaBean

Nutch

Lucene

Crawlzilla System Management

Tomcat

Hadoop

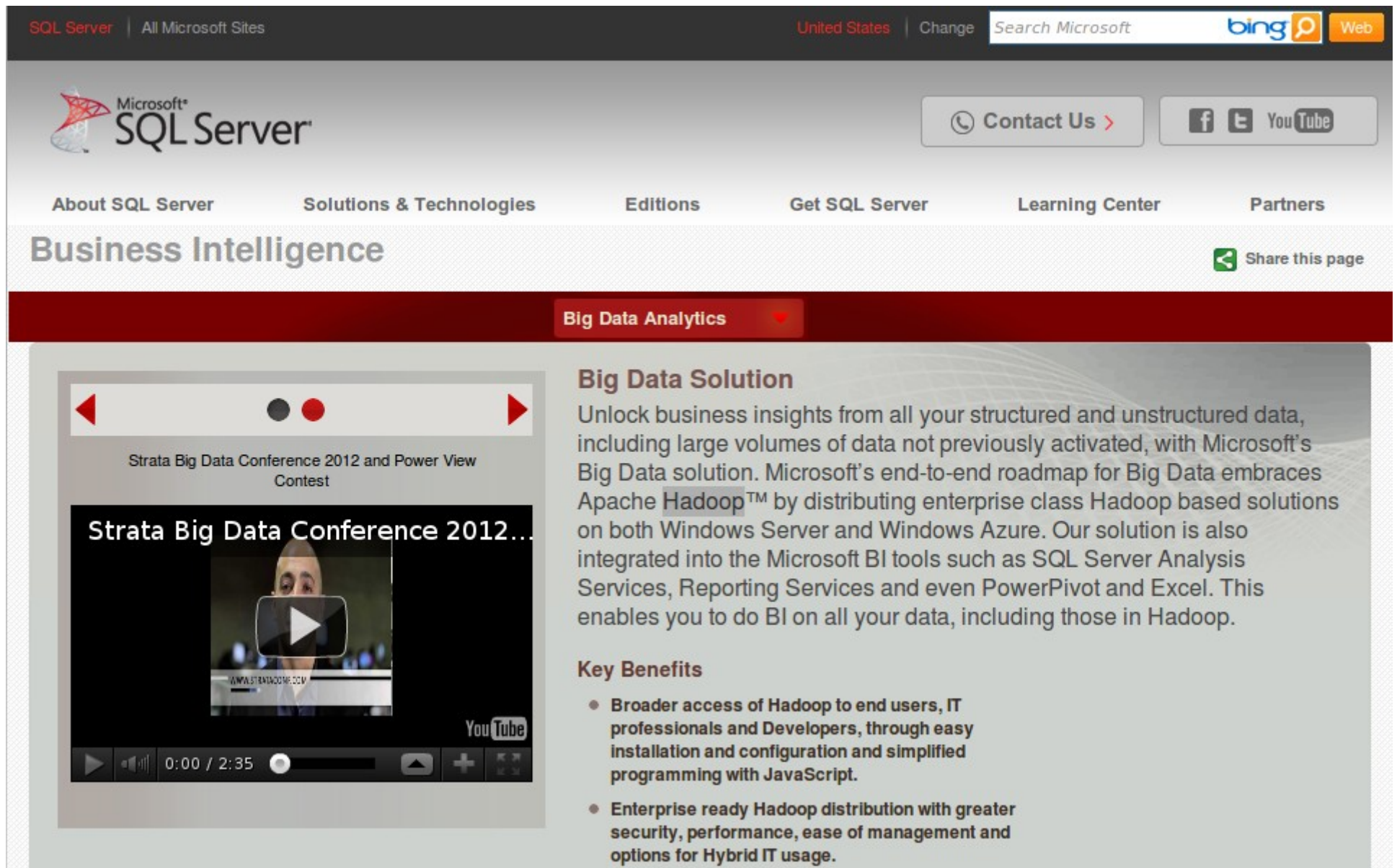
PC1

PC2

PC3

# Microsoft love Hadoop, too

## 微軟幫 Azure 還有 SQL Server 都接上 Hadoop



SQL Server | All Microsoft Sites | United States | Change | Search Microsoft | bing | Web

Microsoft SQL Server

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About SQL Server | Solutions & Technologies | Editions | Get SQL Server | Learning Center | Partners

### Business Intelligence

Share this page

#### Big Data Analytics

#### Big Data Solution

Unlock business insights from all your structured and unstructured data, including large volumes of data not previously activated, with Microsoft's Big Data solution. Microsoft's end-to-end roadmap for Big Data embraces Apache Hadoop™ by distributing enterprise class Hadoop based solutions on both Windows Server and Windows Azure. Our solution is also integrated into the Microsoft BI tools such as SQL Server Analysis Services, Reporting Services and even PowerPivot and Excel. This enables you to do BI on all your data, including those in Hadoop.

#### Key Benefits

- Broader access of Hadoop to end users, IT professionals and Developers, through easy installation and configuration and simplified programming with JavaScript.
- Enterprise ready Hadoop distribution with greater security, performance, ease of management and options for Hybrid IT usage.

參考來源：Big Data Solution | Microsoft SQL Server 2008 R2

<http://www.microsoft.com/sqlserver/en/us/solutions-technologies/business-intelligence/big-data-solution.aspx>

# Oracle love Hadoop, too

## Oracle 也接上 Hadoop



CNET > News > Software, Interrupted

## Cloudera teams up to connect Oracle and Hadoop

Cloudera and Quest software are partnering to provide connectivity between Oracle and Hadoop.



by [Dave Rosenberg](#) | June 21, 2010 5:30 AM PDT

[Follow](#)

This week [Cloudera](#), a provider of software and services for the Apache Hadoop project, is set to announce a partnership with [Quest Software](#) to develop, support, and distribute an Oracle connector for Hadoop.





# Hinet Application of Big Data

## 中華電信已經在做的海量資料應用

Business  
Next 數位時代

### 中華電信：分析駭客行為，拓展對外新服務

撰文者：趙郁竹

發表日期：2012-03-06



[214期雜誌精選]

全球最大的中華電信提供行動電話、市話、寬頻固網、MOD……，各種業務服務，加起來的用戶數就有3000萬，比全台灣人口還多，光是單月帳務數量就高達100億筆資料。除了電信、寬頻服務，還有日益增加的數位服務、行動增值服務，從服務內容到客戶端，累積出的資料相當驚人。

「資料量越來越大，日常分析工作需要很多時間，但新的運算技術有效解決了這個問題，」中華電信資訊處處長陳明仕說。2010年開始，因為中華電信本身的資料運算需求，採用分散式運算架構Hadoop技術，打造出大資料運算平台，不但解決了自身的資料問題，還能對外提供資料運算應用。

以MOD為例，一天有幾千萬筆資料，如何找出使用者在什麼時段做了什麼事？廣告效益又如何？「用傳統的方法，需要400分鐘才能分析完；用Hadoop大資料平台，13分鐘就能解決，節省非常多時間，」他說。

#### 追蹤再拆解

大資料運算技術除了節省時間，還能防止駭客入侵。「駭客的攻擊行為都有模式可循，」陳明仕解釋，就像球賽一樣，了解進攻模式就能防守。用戶的資料保護是第一要務，因此透過行為模式分析，能有效保護企業資訊安全，也保障客戶的個資安全。

參考來源：中華電信：分析駭客行為，拓展對外新服務，發表日期：2012-03-06

<http://www.bnext.com.tw/print/article/id/22333>

# Hinet Application of Big Data

## 中華電信已經在做的海量資料應用

IT ithome.com.tw

### 中華電信用Hadoop技術分析通話明細

READ LATER

面對資料快速成長以及非結構性資料的增加，中華電信資訊處第四科科長楊秀一表示，中華電信近來利用Hadoop雲端運算技術自行開發了一個專門用來分析非結構化資料的巨量資料（Big Data）運算平臺，嘗試在資料進到資料倉儲系統之前，先進行資料的分析與處理以減少資料倉儲的資料量。

近年來行動語音市場趨於飽和，為了掌握用戶特性進行客製化行銷，一份資料要進行分析，就會被多次複製，因此即使用戶增加趨緩，但中華電信擁有的資料量仍快速暴增。

中華電信用來分析的資料模型最早於10多年前已有雛形，但當初主要用於行動語音分析。一直到2009年，他們完整導入Teradata的電信業邏輯資料模型cLDM 9.0版，整合更多電信服務的用戶資料。楊秀一表示，當初導入該模型的目的主要是為了整合行動語音、固網、數據的資料，進行以人為中心的分析模式。在導入之前，中華電信的資料模型是以設備為中心，因為不同設備的記錄資料儲存在不同的資料庫，無法進行整合性的分析。

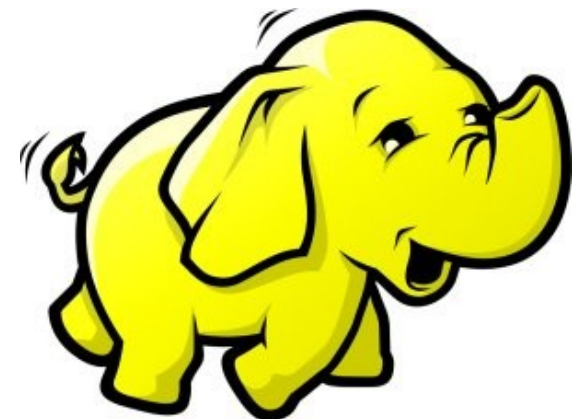
參考來源：中華電信用 Hadoop 技術分析通話明細，發表日期：2011-06-12  
<http://www.ithome.com.tw/itadm/article.php?c=68023>



# Hadoop 簡介：源起與術語

Introduction to Hadoop : History and Terminology

**Jazz Wang**  
**Yao-Tsung Wang**  
**jazz@nchc.org.tw**



# What is Hadoop ?

用一句話解釋 **Hadoop** 是什麼 ??

*Hadoop is a **software platform** that lets one easily write and run applications that **process vast amounts of data.***

**Hadoop** 是一個讓使用者簡易撰寫並執行處理海量資料應用程式的軟體平台。

亦可以想像成一個處理海量資料的生產線，只須學會定義 **map** 跟 **reduce** 工作站該做哪些事情。

# Features of Hadoop ...

## **Hadoop** 這套軟體的特色是 ...

- **海量 Vast Amounts of Data**
  - 擁有儲存與處理大量資料的能力
  - Capability to **STORE** and **PROCESS** vast amounts of data.
- **經濟 Cost Efficiency**
  - 可以用在由一般 PC 所架設的叢集環境內
  - Based on large clusters built of **commodity hardware**.
- **效率 Parallel Performance**
  - 透過分散式檔案系統的幫助，以致得到快速的回應
  - With the help of HDFS, Hadoop **have better performance**.
- **可靠 Robustness**
  - 當某節點發生錯誤，能即時自動取得備份資料及佈署運算資源
  - Robustness to add and remove computing and storage resource without shutdown entire system.

# Founder of Hadoop – Doug Cutting

**Hadoop** 這套軟體的創辦人 **Doug Cutting**

Doug Cutting Talks About The Founding Of Hadoop

clouderahadoop

9 部影片

編輯訂閱項目

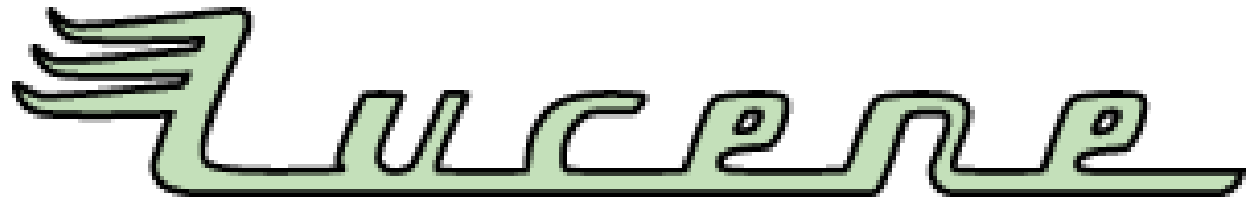


Doug Cutting Talks About The Founding Of Hadoop

<http://www.youtube.com/watch?v=qxC4urJOchs>

# History of Hadoop ... 2002~2004

## *Hadoop* 這套軟體的歷史源起 ... 2002~2004



- Lucene

- <http://lucene.apache.org/>
- 用Java 設計的高效能文件索引引擎API
- a high-performance, full-featured **text search engine library** written entirely in **Java**.
- 索引文件中的每一字，讓搜尋的效率比傳統逐字比較還要高的多
- Lucene create an **inverse index** of every word in different documents. It enhance performance of text searching.

# History of Hadoop ... 2002~2004

## *Hadoop* 這套軟體的歷史源起 ... 2002~2004

- Nutch



- <http://nutch.apache.org/>
- Nutch 是基於開放原始碼所開發的網站搜尋引擎
- Nutch is open source **web-search** software.
- 利用Lucene 函式庫開發
- It builds on **Lucene and Solr**, adding web-specifics, such as a **crawler**, a **link-graph database**, parsers for HTML and other document formats, etc.





# Three Gifts from Google ....

## 來自 **Google** 的三個禮物 ....

- Nutch 後來遇到儲存大量網站資料的瓶頸
- Nutch encounter storage issue
- Google 在一些會議分享他們的三大關鍵技術
- Google shared their design of web-search engine
  - SOSP 2003 : “The Google File System”
  - <http://labs.google.com/papers/gfs.html>
  - OSDI 2004 : “MapReduce : Simplified Data Processing on Large Cluster”
  - <http://labs.google.com/papers/mapreduce.html>
  - OSDI 2006 : “Bigtable: A Distributed Storage System for Structured Data”
  - <http://labs.google.com/papers/bigtable-osdi06.pdf>



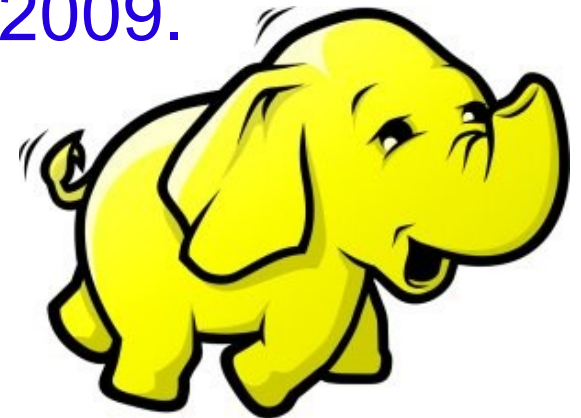
# History of Hadoop ... 2004 ~ Now

## Hadoop 這套軟體的歷史源起 ... 2004 ~ Now

- Dong Cutting reference from Google's publication
- Added DFS & MapReduce implement to Nutch
- According to **user feedback** on the mail list of Nutch ....
- Hadoop became separated project **since Nutch 0.8**
- Nutch DFS → Hadoop Distributed File System (HDFS)
- **Yahoo** hire Dong Cutting to build a team of web search engine at **year 2006**.
  - Only **14 team members** (engineers, clusters, users, etc.)
- Dong Cutting joined Cloudera at year 2009.

**YAHOO!**

 cloudera



# Who Use Hadoop ??

有哪些公司在用 **Hadoop** 這套軟體 ??

- **Yahoo** is the key contributor currently.
- **IBM** and **Google** teach Hadoop in universities ...
- [http://www.google.com/intl/en/press/pressrel/20071008\\_ibm\\_univ.html](http://www.google.com/intl/en/press/pressrel/20071008_ibm_univ.html)
- **The New York Times** used **100 Amazon EC2 instances** and a Hadoop application to process **4TB of raw image TIFF data** (stored in S3) into **11 million finished PDFs** in the space of **24 hours** at a computation cost of about **\$240** (not including bandwidth)
  - from <http://en.wikipedia.org/wiki/Hadoop>
- <http://wiki.apache.org/hadoop/AmazonEC2>
- <http://wiki.apache.org/hadoop/PoweredBy>
  - A9.com
  - ADSDAQ by Contextweb
  - EHarmony
  - Facebook
  - Fox Interactive Media
  - IBM
  - ImageShack
  - ISI
  - Joost
  - Last.fm
  - Powerset
  - The New York Times
  - Rackspace
  - Veoh
  - Metaweb

# Hadoop in production run ....

## 商業運轉中的 **Hadoop** 應用 ....

- February 19, 2008
- Yahoo! Launches World's Largest Hadoop Production Application
- <http://developer.yahoo.net/blogs/hadoop/2008/02/yahoo-worlds-largest-production-hadoop.html>

Number of links between pages in the index	roughly 1 trillion links
Size of output	over 300 TB, compressed!
Number of cores used to run single Map-Reduce job	over 10,000
Raw disk used in the production cluster	over 5 Petabytes

# Hadoop in production run ....

## 商業運轉中的 *Hadoop* 應用 ....

- September 30, 2008
- Scaling Hadoop to 4000 nodes at Yahoo!
- [http://developer.yahoo.net/blogs/hadoop/2008/09/scaling\\_hadoop\\_to\\_4000\\_nodes\\_a.html](http://developer.yahoo.net/blogs/hadoop/2008/09/scaling_hadoop_to_4000_nodes_a.html)

<b>Total Nodes</b>	<b>4000</b>
<b>Total cores</b>	<b>30000</b>
<b>Data</b>	<b>16PB</b>

	<b>500-node cluster</b>		<b>4000-node cluster</b>	
	<b>write</b>	<b>read</b>	<b>write</b>	<b>read</b>
<b>number of files</b>	990	990	14,000	14,000
<b>file size (MB)</b>	320	320	360	360
<b>total MB processes</b>	316,800	316,800	5,040,000	5,040,000
<b>tasks per node</b>	2	2	4	4
<b>avg. throughput (MB/s)</b>	<b>5.8</b>	<b>18</b>	<b>40</b>	<b>66</b>

# Comparison between Google and Hadoop

## *Google* 與 *Hadoop* 的比較表

<b>Develop Group</b>	Google	Apache
<b>Sponsor</b>	Google	Yahoo, Amazon
<b>Algorithm Method</b>	MapReduce	MapReduce
<b>Resource</b>	open document	open source
<b>File System (MapReduce)</b>	GFS	HDFS
<b>Storage System (for structure data)</b>	big-table	HBase
<b>Search Engine</b>	Google	Nutch
<b>OS</b>	Linux	Linux / GPL

# Why should we learn Hadoop ?

## 為何需要學習 **Hadoop ??**

[Search Jobs](#) [Browse Jobs](#) [Local Jobs](#) [Salaries](#) [Employment Trends](#)

**simplyhired**<sup>®</sup>  
job search made simple

Employment Trends

Xen, Hyper-V, Hadoop

Tip: You can compare trends by separating them with commas.

Xen, Hyper-v, Hadoop Trends



### Xen, Hyper-v, Hadoop Job Trends

This graph displays the percentage of jobs with your search terms anywhere in the job listing. Since November 2008, the following has occurred:

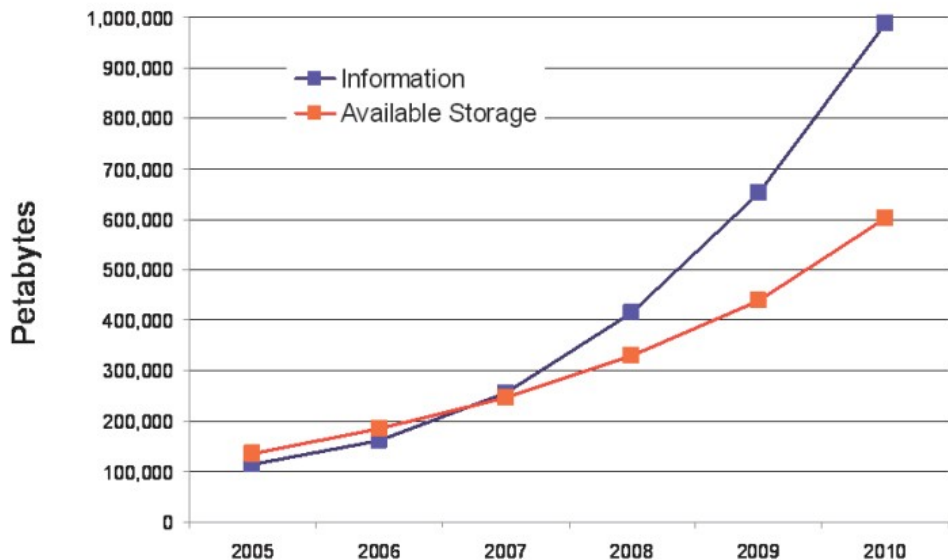
- [Xen jobs](#) increased 141%
- [Hyper-v jobs](#) increased 551%
- [Hadoop jobs](#) did not change or there is no data available

1. Data Explore  
資訊大爆炸

2. Data Mining Tool  
方便作資料探勘的工作

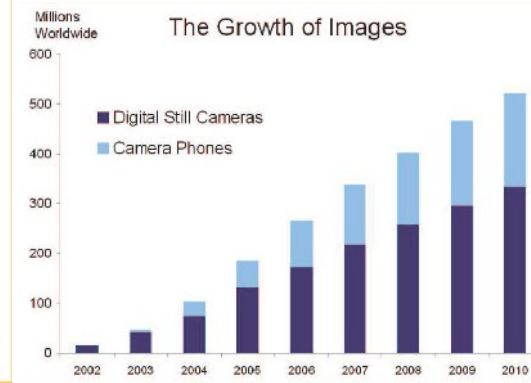
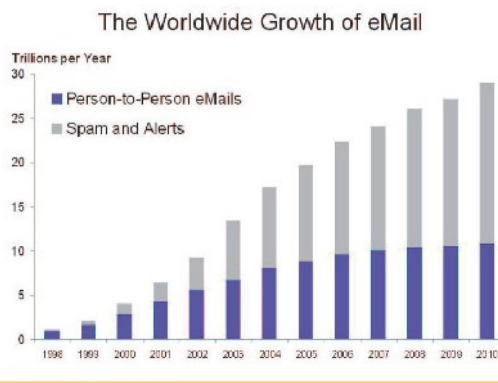
3. Looking for Jobs  
好找工作!!

# Information Versus Available Storage



# 2007 Data Explore

**Top 1 : Human Genomics - 7000 PB / Year**  
**Top 2 : Digital Photos - 1000 PB+ / Year**  
**Top 3 : E-mail (no Spam) - 300 PB+ / Year**



Source: <http://www.emc.com/collateral/analyst-reports/expanding-digital-idc-white-paper.pdf>

Source: IDC, 2007

Source: IDC, 2007



Source: [http://lib.stanford.edu/files/sec\\_pasig\\_dtc.pdf](http://lib.stanford.edu/files/sec_pasig_dtc.pdf)

Particle Physics Large Hadron Collider (15PB)	Human Genomics (7000PB) 1GB / person 200PB+ captured 200% CAGR	World Wide Web (~1PB)	Wikipedia (10GB) 100% CAGR
Annual Email Traffic, no spam (300PB+)	Internet Archive (1PB+)	Estimated On-line RAM in Google (8PB)	Personal Digital Photos (1000PB+) 100% CAGR
200 of London's Traffic Cams (8TB/day)	2004 Walmart Transaction DB (500TB)	Typical Oil Company (350TB+)	Merck Bio Research DB (1.5TB/qtr)
UPMC Hospitals Imaging Data (500TB/yr)	MIT Babyltalk Speech Experiment (1.4PB)	Terashake Earthquake Model of LA Basin (1PB)	One Day of Instant Messaging in 2002 (750GB)
Total digital data to be created this year <b>270,000PB</b> (IDC)			

Phillip B. Gibbons, Data-Intensive Computing Symposium

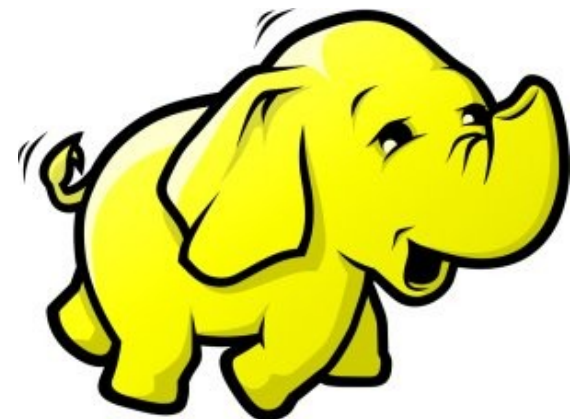




# Hadoop 專業術語

## Introduction to Hadoop Terminology

**Jazz Wang**  
**Yao-Tsung Wang**  
**[jazz@nchc.org.tw](mailto:jazz@nchc.org.tw)**



# Two Key Elements of Operating System

## 作業系統兩大關鍵組成元素

Scheduler  
程序排程



File System  
檔案系統



# Terminologies of Hadoop

## Hadoop 文件中的專業術語

- Job
  - 任務
- Task
  - 小工作
- JobTracker
  - 任務分派者
- TaskTracker
  - 小工作的執行者
- Client
  - 發起任務的客戶端
- Map
  - 應對
- Reduce
  - 總和



- Namenode
  - 名稱節點
- Datanode
  - 資料節點
- Namespace
  - 名稱空間
- Replication
  - 副本
- Blocks
  - 檔案區塊 (64M)
- Metadata
  - 屬性資料



# Two Key Roles of HDFS

## HDFS 軟體架構的兩種關鍵角色

### 名稱節點 **NameNode**

- **Master Node**
- **Manage NameSpace of HDFS**
- **Control Permission of Read and Write**
- **Define the policy of Replication**
- **Audit and Record the NameSpace**
- **Single Point of Failure**

### 資料節點 **DataNode**

- **Worker Nodes**
- **Perform operation of Read and Write**
- **Execute the request of Replication**
- **Multiple Nodes**

# Two Key Roles of Job Scheduler

## 程序排程的兩種關鍵角色

### JobTracker

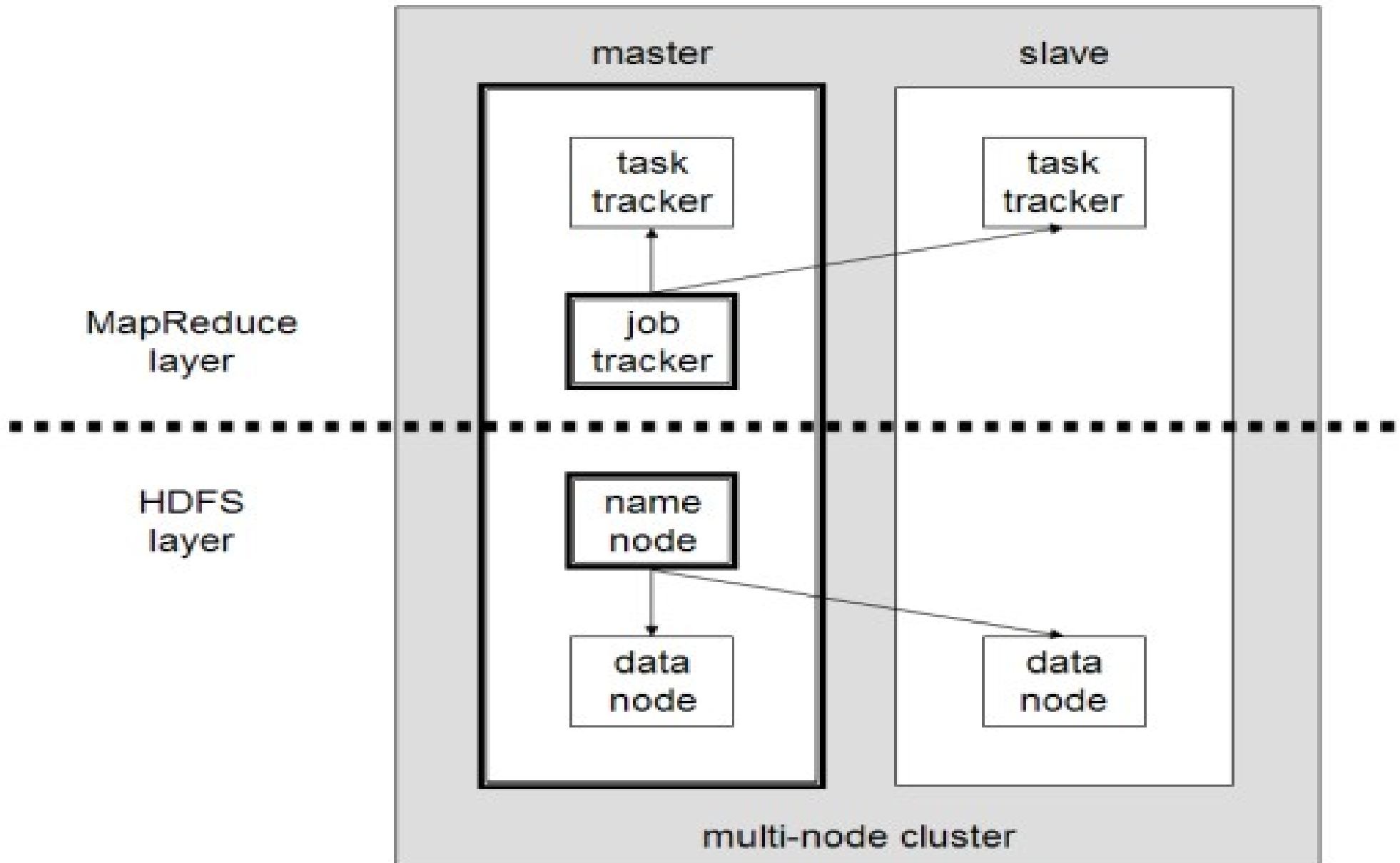
- **Master Node**
- **Receive Jobs from Hadoop Clients**
- **Assigned Tasks to TaskTrackers**
- **Define Job Queuing Policy, Priority and Error Handling**
- **Single Point of Failure**

### TaskTracker

- **Worker Nodes**
- **Excute Mapper and Reducer Tasks**
- **Save Results and report task status**
- **Multiple Nodes**

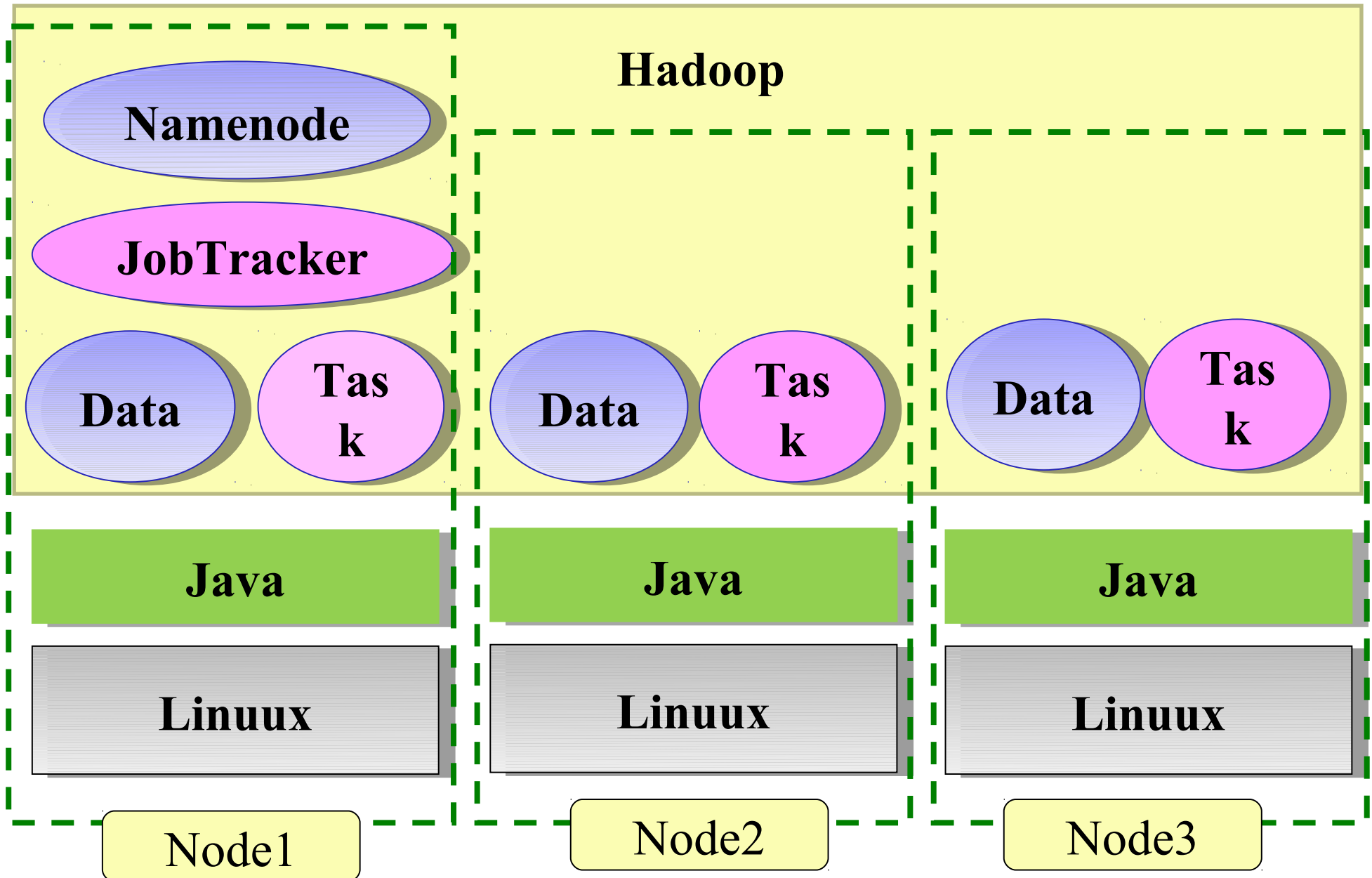
# Different Roles of Hadoop Architecture

## *Hadoop* 軟體架構中的不同角色



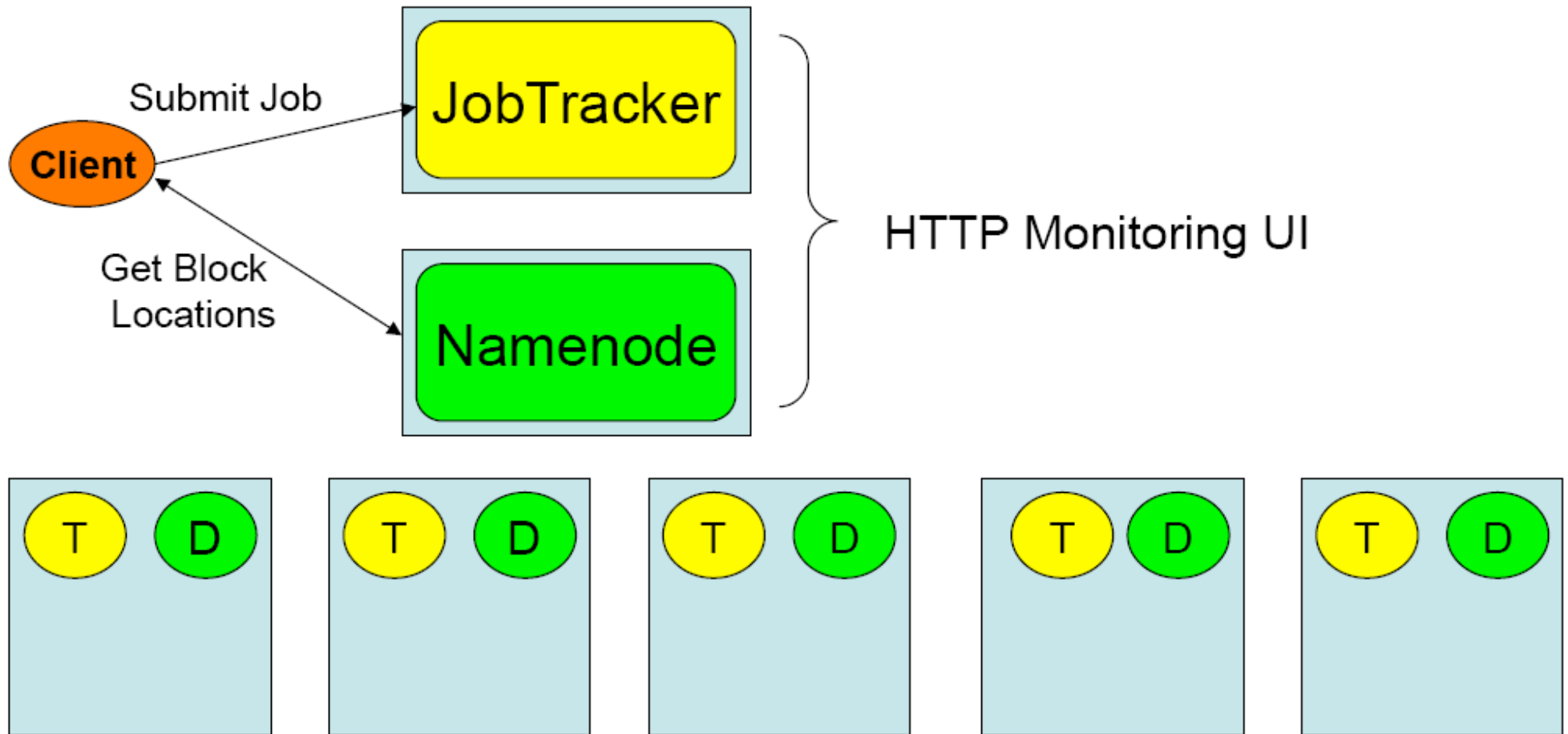
# Distributed Operating System of Hadoop

**Hadoop** 建構成一個分散式作業系統



# About Hadoop Client ...

## 不在雲裡的 *Hadoop Client*





# What we learn today ?

## WHAT

Hadoop 是運算海量資料的軟體平台 !!

hadoop is a software platform to process vast amount of data!!

## WHO

始祖是 Doug Cutting , Apache 社群支持 , Yahoo 贊助

From Doug Cutting to Apache Community, Yahoo and more !

## WHEN

Hadoop 是 2004 年從 Nutch 分裂出來的專案 !!

Hadoop became separate project since year 2004 !!

## WHY

資料大爆炸、資料探勘、找工作

Data Explore, Data Mining, Jobs !!

## HOW

建構在大型的個人電腦叢集之上

Install on large clusters built of commodity hardware !!



## Questions?

Slides - <http://trac.nchc.org.tw/cloud>

**Jazz Wang**  
**Yao-Tsung Wang**  
**jazz@nchc.org.tw**



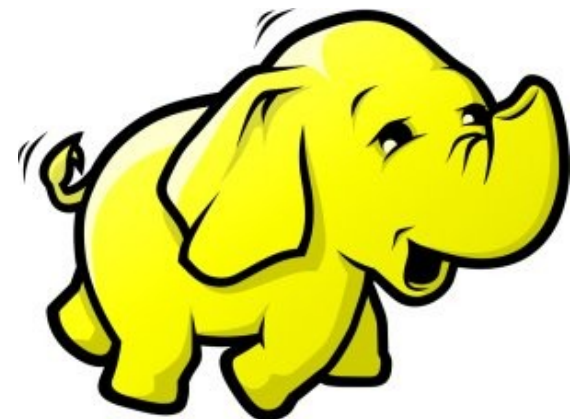
Powered by DRBL



# HDFS 簡介

Introduction to Hadoop Distributed File System

**Jazz Wang**  
**Yao-Tsung Wang**  
**jazz@nchc.org.tw**



# What is HDFS ??

## 什麼是 **HDFS** ??

- **Hadoop Distributed File System**

- 實現類似 Google File System 分散式檔案系統
- Reference from Google File System.
- 一個易於擴充的分散式檔案系統，目的為對大量資料進行分析
- **A scalable distributed file system for large data analysis .**
- 運作於廉價的普通硬體上，又可以提供容錯功能
- **based on commodity hardware with high fault-tolerant.**
- 給大量的用戶提供總體性能較高的服務
- **It have better overall performance to serve large amount of users.**

# Features of HDFS ...

## **HDFS** 的特色是 ...

- **硬體錯誤容忍能力 Fault Tolerance**
  - 硬體錯誤是正常而非異常
  - Failure is the norm rather than exception
  - 自動恢復或故障排除
  - automatic recovery or report failure
- **串流式的資料存取 Streaming data access**
  - 批次處理多於用戶交互處理
  - Batch processing rather than interactive user access.
  - 高 Throughput 而非低 Latency
  - High aggregate data bandwidth (throughput)

# Features of HDFS ...

## HDFS 的特色是 ...

- **大規模資料集 Large data sets and files**
  - 支援 Petabytes 等級的磁碟空間
  - Support Petabytes size
- **一致性模型 Coherency Model**
  - 一次寫入，多次存取 Write-once-read-many
  - 簡化一致性處理問題 This assumption simplifies coherency
- **在地運算 Data Locality**
  - 到資料的節點上計算 > 將資料從遠端複製過來計算
  - “move compute to data” > “move data to compute”
- **異質平台移植性 Heterogeneous**
  - 即使硬體不同也可移植、擴充
  - HDFS could be deployed on different hardware

# Parallel Computing using NFS storage

使用 **NFS** 進行平行運算

NFS Client RAM

NFS Client Bridge

NFS Client NIC

Bus I/O (2)

NFS Client CPU

Network I/O

NFS Server NIC

Bus I/O (1)

NFS Server RAM

NFS Server Bridge

NFS Server CPU

NFS Server Disk

Disk I/O

# Parallel Computing using HDFS

使用 **HDFS** 進行平行運算

TaskTracker RAM

TaskTracker Bridge

Disk I/O x N Node

DataNode Local Disk

Bus I/O (2)

TaskTracker CPU

Network I/O

TaskTracker NIC

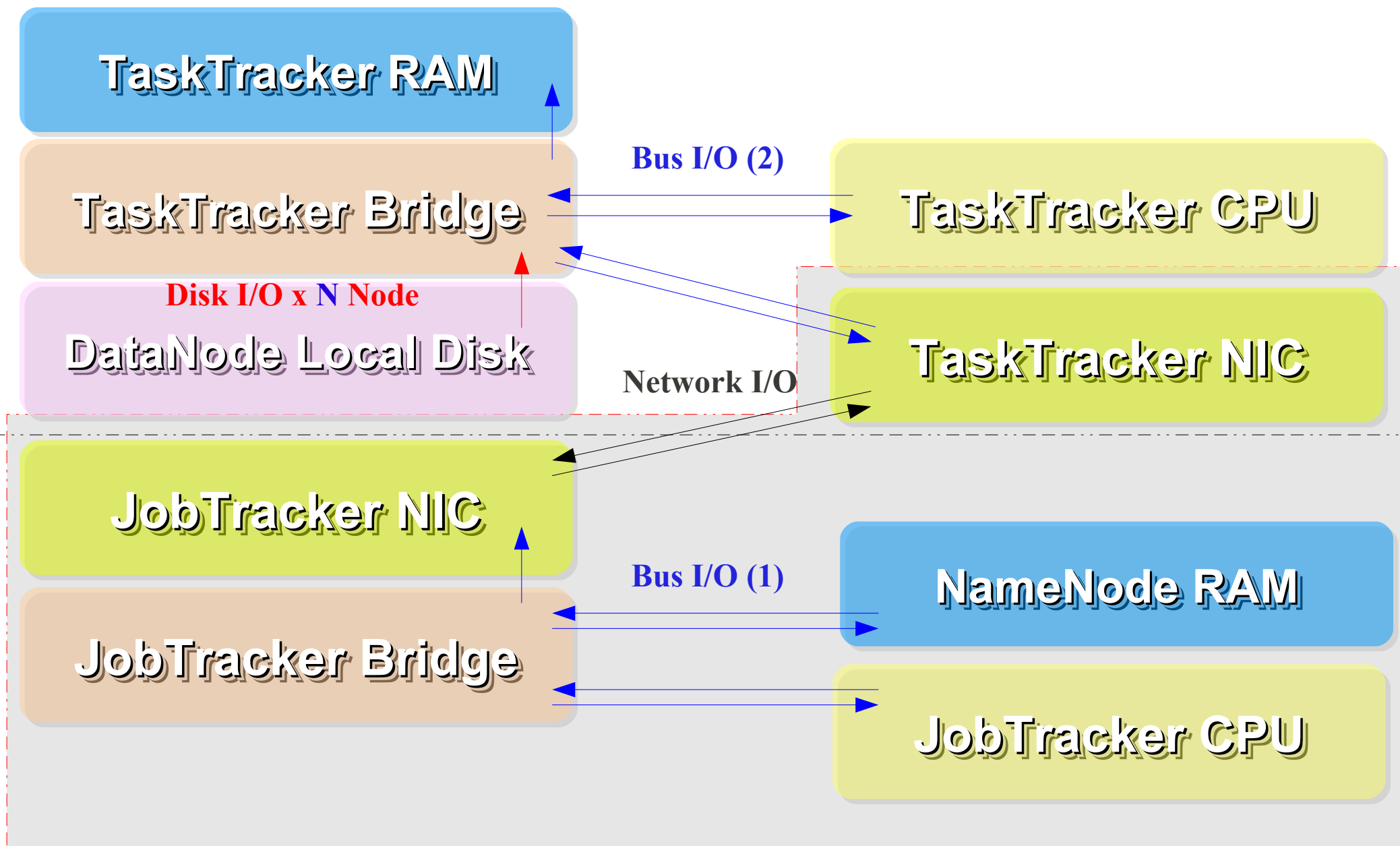
JobTracker NIC

Bus I/O (1)

NameNode RAM

JobTracker Bridge

JobTracker CPU

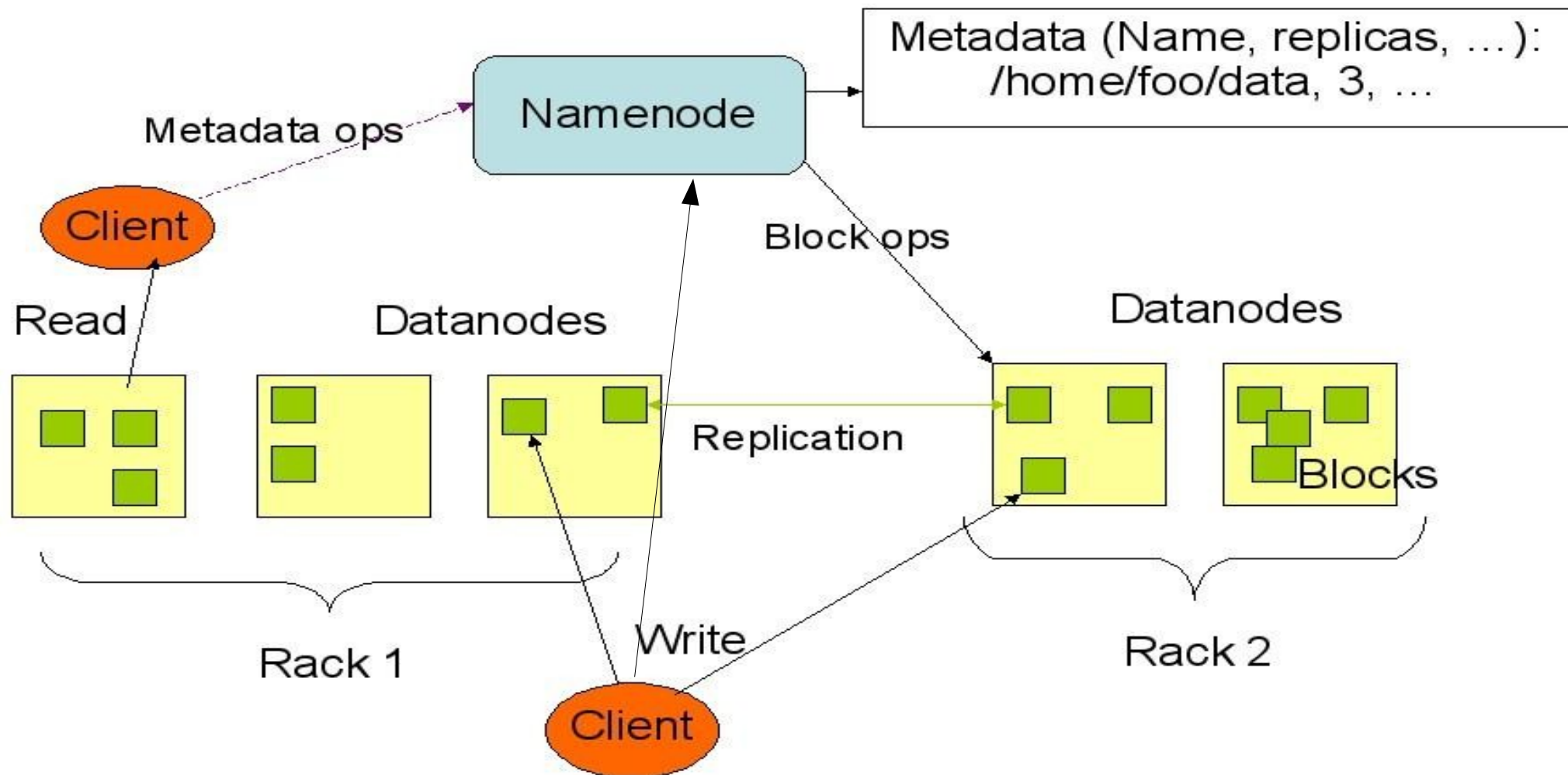




# How HDFS manage data ...

## *HDFS* 如何管理資料 ...

HDFS Architecture



# How does HDFS work ...

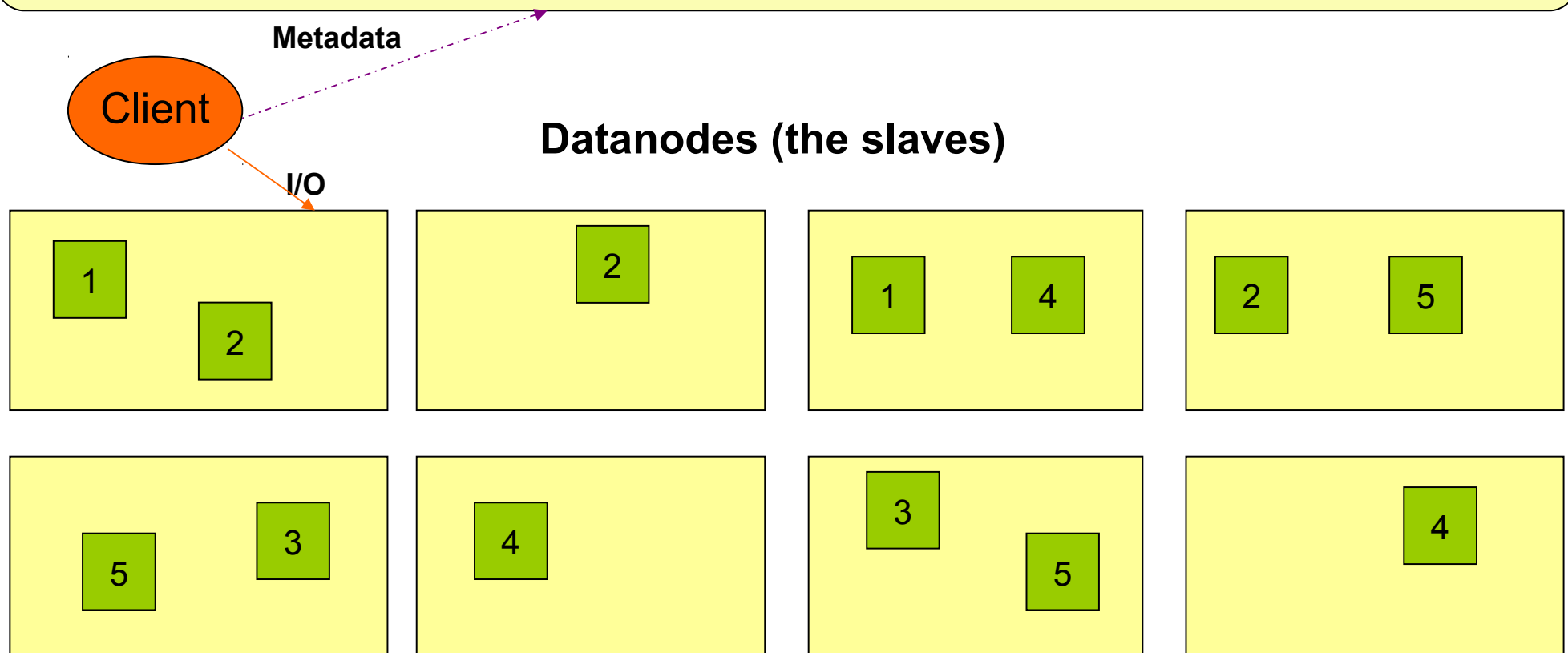
## *HDFS* 如何運作 ...

Namenode (the master)

Path and Filename – **Replication** , **blocks**

name:/users/joeYahoo/myFile - copies:2, blocks:{1,3}

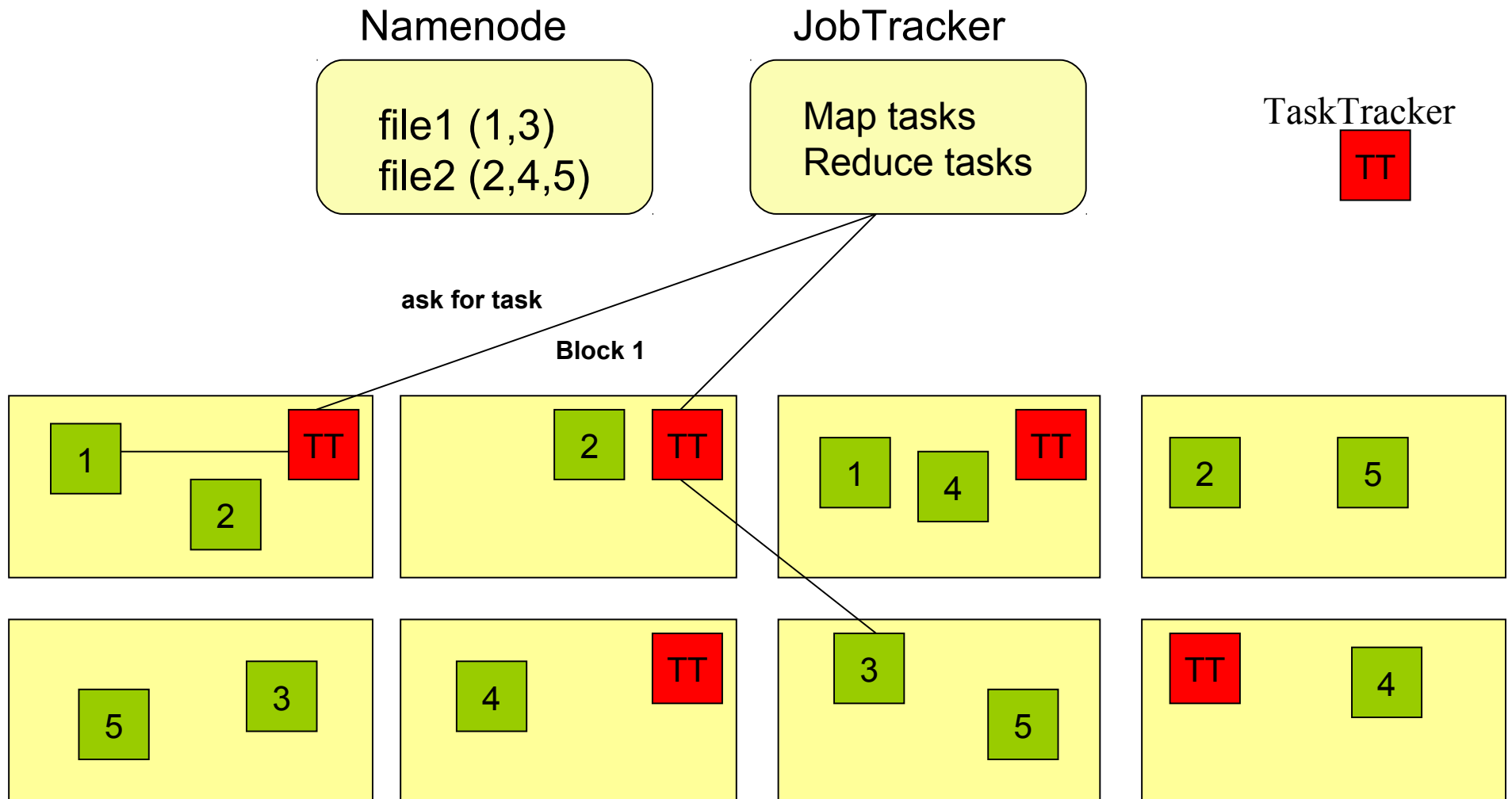
name:/users/bobYahoo/someData.gzip, copies:3, blocks:{2,4,5}



# About Data locality ...

## **HDFS** 如何達成在地運算 ...

- Increase reliability and read bandwidth
  - robustness : read replication while found any failure
  - High read bandwidth : distribute read ( but increase write bottleneck )



# About Fault Tolerance ...

## **HDFS** 如何達成容錯機制 ...

資料崩毀  
Data Corrupt

網路或資料  
節點失效  
Network Fault  
DataNode Fault

名稱節點錯誤  
NameNode Fault

- 資料完整性 Data integrity
  - checked with CRC32
  - 用副本取代出錯資料
  - Replcae corrupt block with replication one
- Heartbeat
  - Datanode send **heartbeat** to Namenode
- Metadata
  - FSImage 、 Editlog 為核心印象檔及日誌檔
  - FSImage – core file system mapping image
  - Editlog – like. SQL transaction log
  - 多份儲存，當名稱節點故障時可以手動復原
  - Multiple backups of FSImage and Editlog
  - Manually recovery while NameNode Fault

# Coherency Model and Performance of HDFS

## **HDFS 的一致性機制與效能 ...**

- **檔案一致性機制 Coherency model of files**
  - 刪除檔案\新增寫入檔案\讀取檔案皆由名稱節點負責
  - NameNode handle the operation of write, read and delete.
- **巨量空間及效能機制 Large Data Set and Performance**
  - 預設每個區塊大小以 64MB 為單位
  - By default, the block size is 64MB
  - 大區塊可提高存取效率
  - Bigger block size will enhance read performance
  - 檔案有可能大過一顆磁碟
  - Single file stored on HDFS might be larger than single physical disk of DataNode.
  - 區塊均勻散佈各節點以分散讀取流量
  - Fully distributed blocks increase throughput of reading.

# POSIX like HDFS commands

## 與 **POSIX** 相似的操作指令 ...

```
jazz@hadoop:~$ hadoop fs
Usage: java FsShell
    [-ls <path>]
    [-lsr <path>]
    [-du <path>]
    [-dus <path>]
    [-count[-q] <path>]
    [-mv <src> <dst>]
    [-cp <src> <dst>]
    [-rm <path>]
    [-rmr <path>]
    [-expunge]
    [-put <localsrc> ... <dst>]
    [-copyFromLocal <localsrc> ... <dst>]
    [-moveFromLocal <localsrc> ... <dst>]
    [-get [-ignoreCrc] [-crc] <src> <localdst>]
    [-getmerge <src> <localdst> [addnl]]
    [-cat <src>]
    [-text <src>]
    [-copyToLocal [-ignoreCrc] [-crc] <src> <localdst>]
    [-moveToLocal [-crc] <src> <localdst>]
    [-mkdir <path>]
    [-setrep [-R] [-w] <rep> <path/file>]
    [-touchz <path>]
    [-test -[ezd] <path>]
    [-stat [format] <path>]
    [-tail [-f] <file>]
    [-chmod [-R] <MODE[,MODE]... | OCTALMODE> PATH...]
    [-chown [-R] [OWNER][:[GROUP]] PATH...]
    [-chgrp [-R] GROUP PATH...]
    [-help [cmd]]
```



## Questions?

Slides - <http://trac.nchc.org.tw/cloud>

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**jazz@nchc.org.tw**



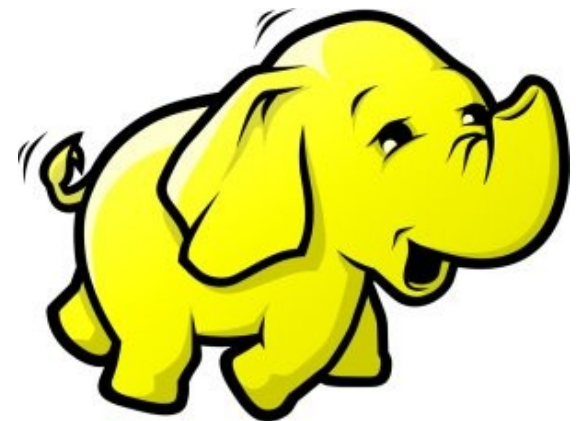
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# MapReduce 簡介

## Introduction to MapReduce

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**[jazz@nchc.org.tw](mailto:jazz@nchc.org.tw)**

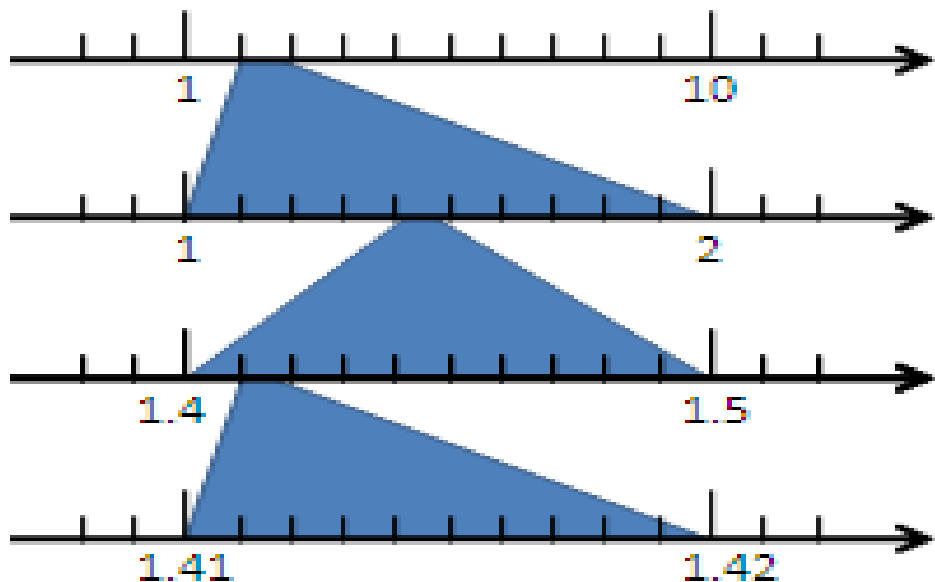




# Divide and Conquer Algorithms

## 分而治之演算法

Example 1:

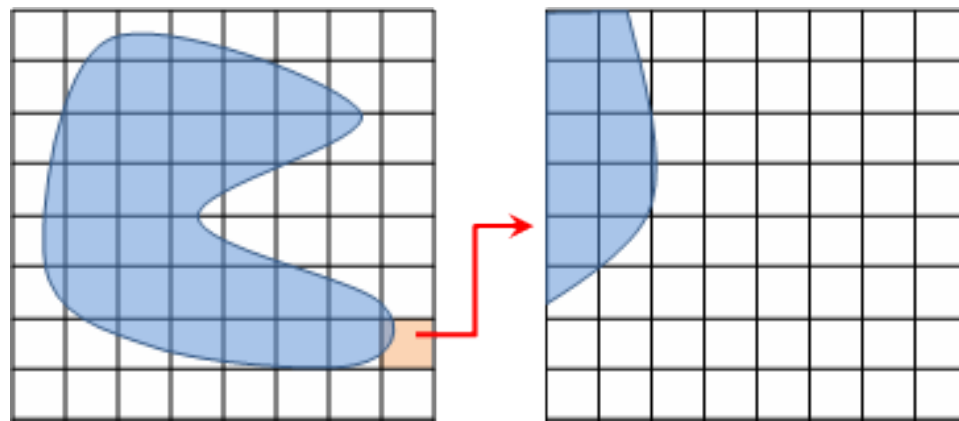


sqrt(2)

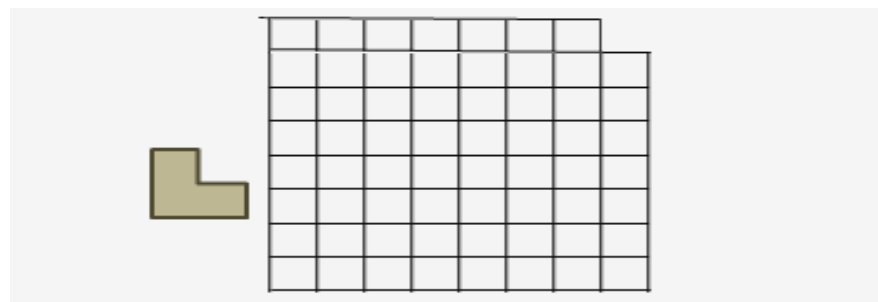
Example 4: The way to climb 5 steps stair within 2 steps each time. 眼前有五階樓梯，每次可踏上一階或踏上兩階，那麼爬完五階共有幾種踏法？

Ex : (1,1,1,1,1) or (1,2,1,1)

Example 2:



Example 3:



# What is MapReduce ??

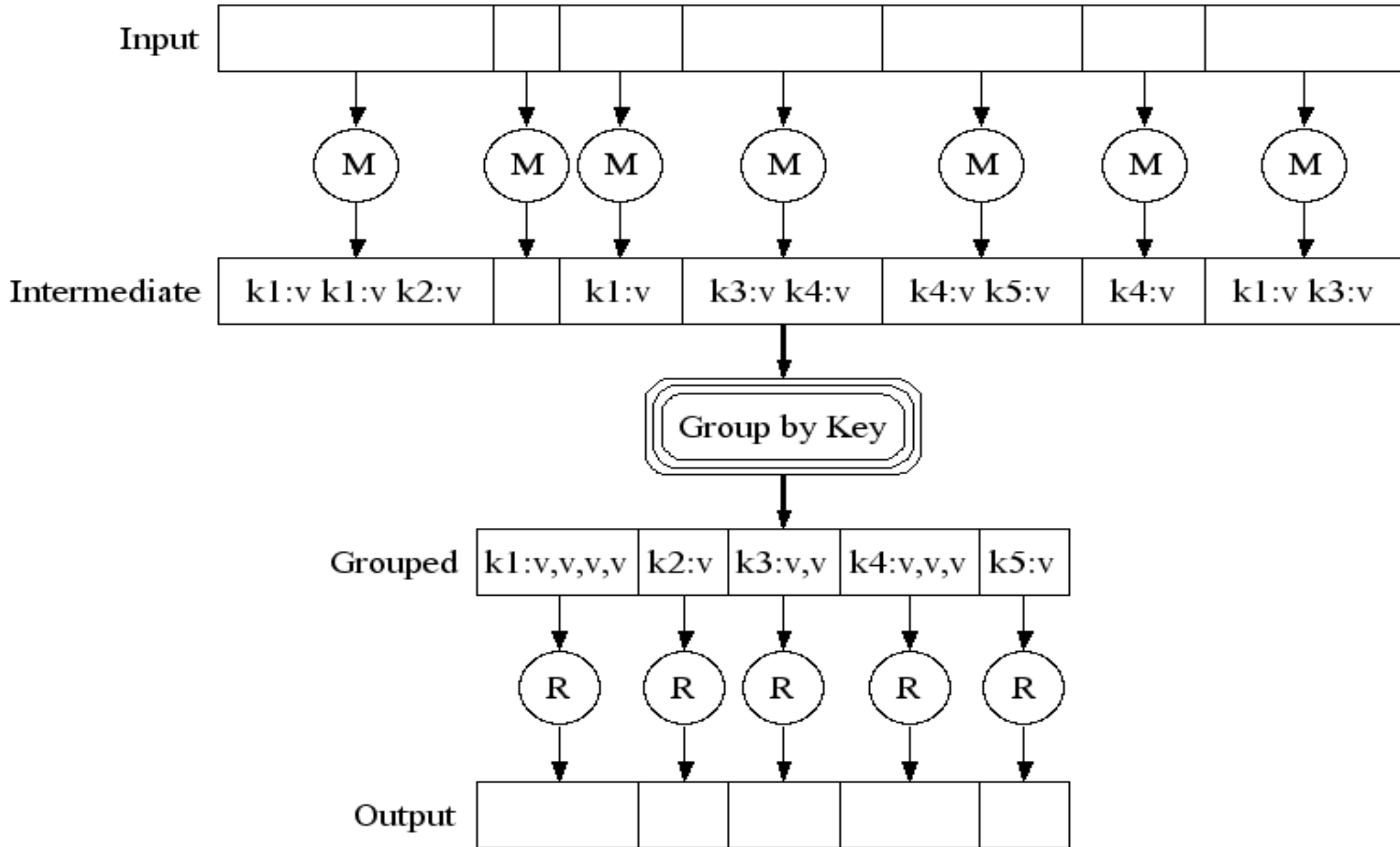
## 什麼是 *MapReduce* ??

- MapReduce 是 Google 申請的軟體專利，主要用來處理大量資料
- MapReduce is a **patented** software framework introduced by **Google** to support distributed computing on large data sets on clusters of computers.
- 啟發自函數編程中常用的 map 與 reduce 函數。
- The framework is inspired by **map** and **reduce** functions commonly used in **functional programming**, although their purpose in the MapReduce framework is not the same as their original forms
  - Map(...):  $N \rightarrow N$ 
    - Ex. [ 1,2,3,4 ] – (**\*2**) -> [ 2,4,6,8 ]
  - Reduce(...):  $N \rightarrow 1$ 
    - [ 1,2,3,4 ] - (**sum**) -> 10
- **Logical view of MapReduce**
  - Map(k1, v1) -> list(k2, v2)
  - Reduce(k2, list (v2)) -> list(k3, v3)

Source: <http://en.wikipedia.org/wiki/MapReduce>

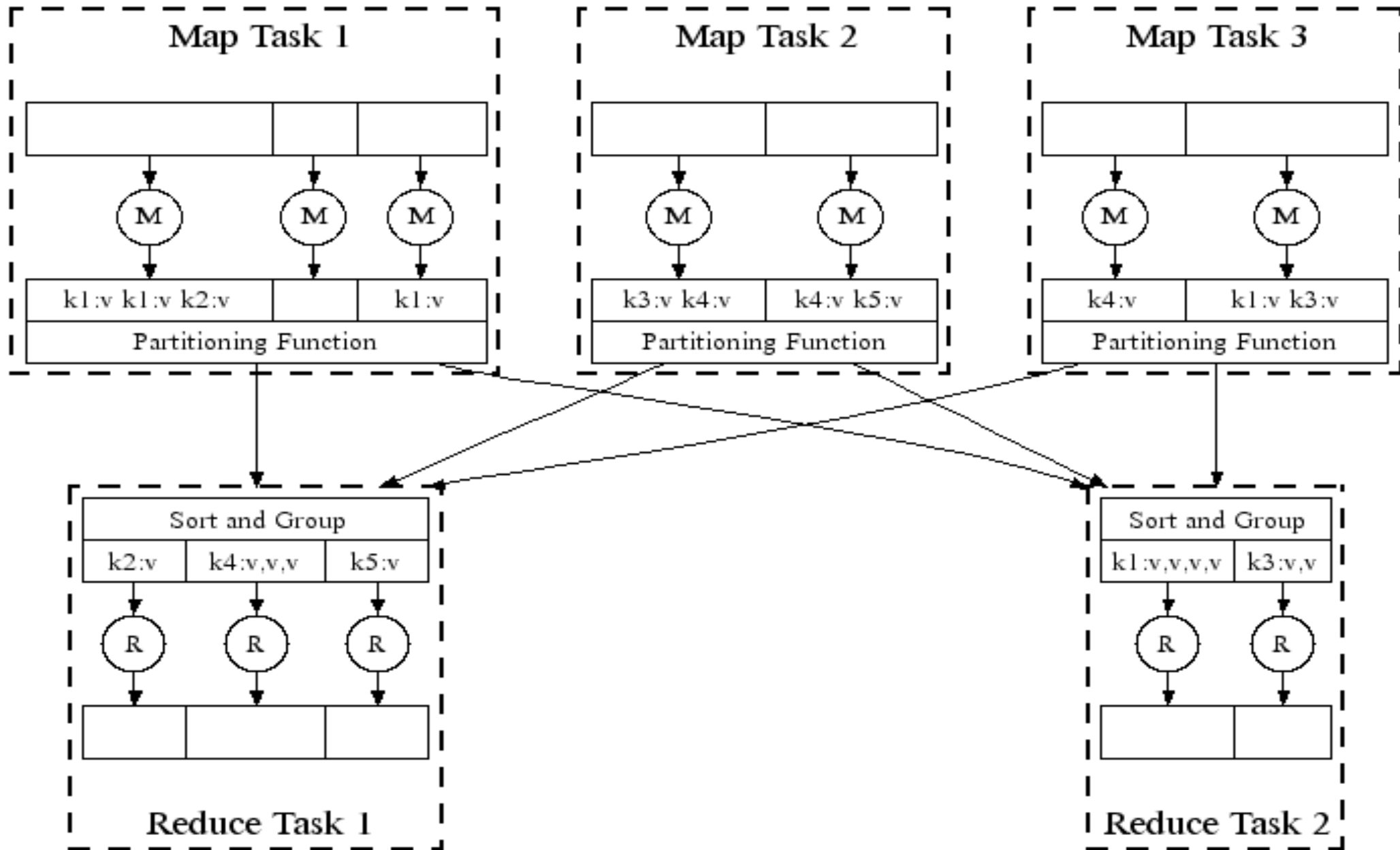
# Google's MapReduce Diagram

## Google 的 MapReduce 圖解



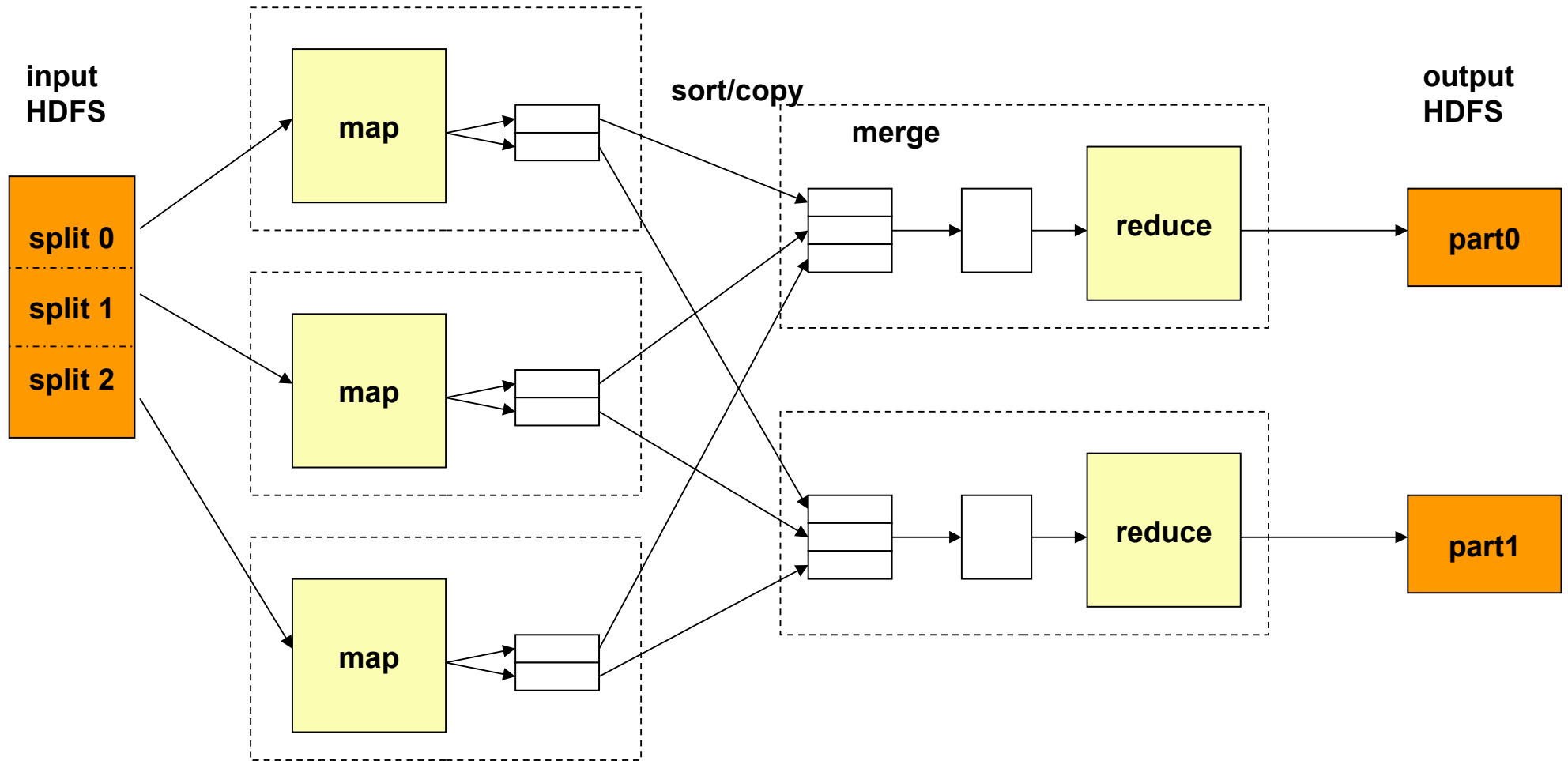
# Google's MapReduce in Parallel

## Google 的 MapReduce 平行版圖解



# How does MapReduce work in Hadoop

## Hadoop MapReduce 運作流程



JobTracker 跟 NameNode 取得需要運算的 blocks

JobTracker 選數個 TaskTracker 來作 Map 運算，產生些中間檔案

JobTracker 將中間檔案整合排序後，複製到需要的 TaskTracker 去

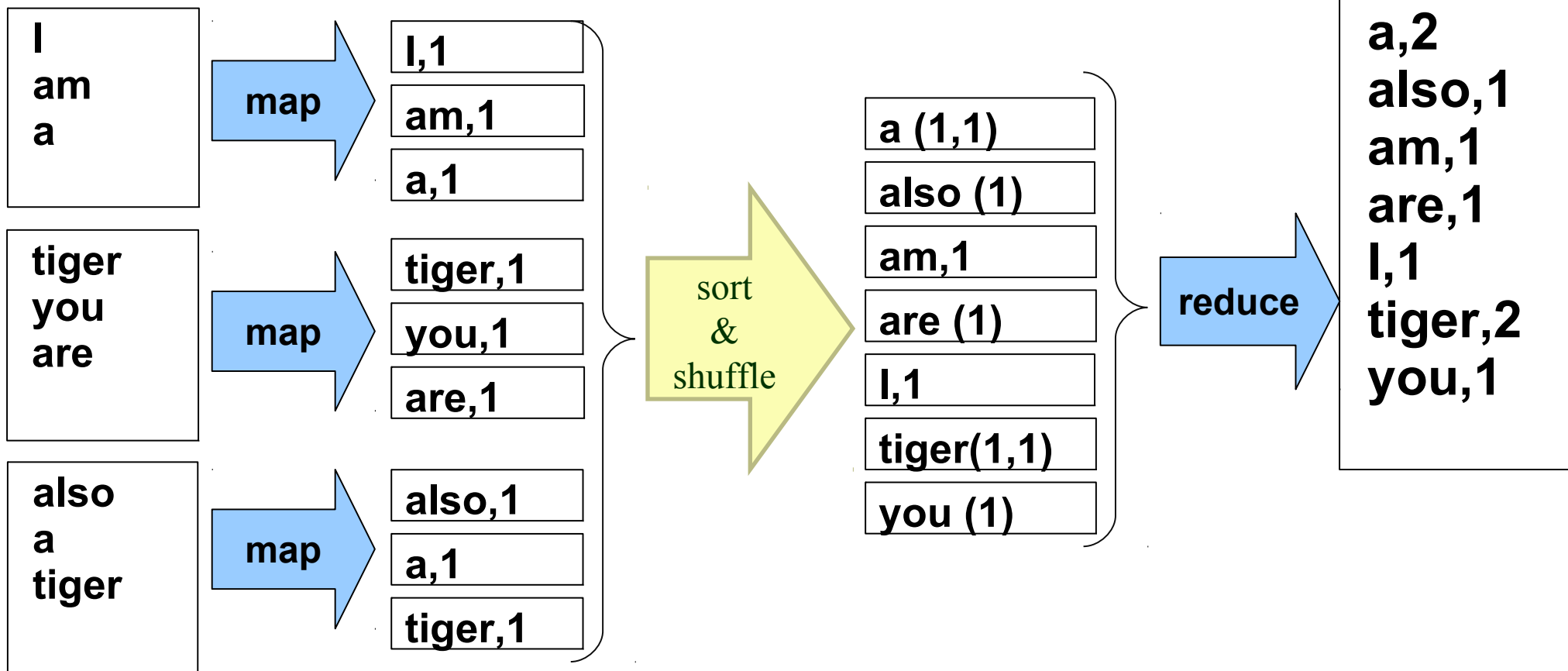
JobTracker 派遣 TaskTracker 作 reduce

reduce 完後通知 JobTracker 與 Namenode 以產生 output

# MapReduce by Example (1)

## MapReduce 運作實例 (1)

I am a tiger, you are also a tiger



JobTracker 先選了三個 Tracker 做 map

Map 結束後，hadoop 進行中間資料的重組與排序

JobTracker 再選一個 TaskTracker 作 reduce

# MapReduce by Example (2)

## MapReduce 運作實例 (2)

$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \rightarrow \begin{bmatrix} \text{sqrt}(a + b) \\ \text{sqrt}(c + d) \end{bmatrix}$

$\begin{bmatrix} 1.0 & 0.0 & 3.0 \\ 3.2 & 0.8 & 32.0 \\ 1.0 & 14.0 & 1.0 \end{bmatrix} \rightarrow ?$

Input File

```
0 0 1.0 // A[0][1] = 1.0
0 1 0.0 // A[0][1] = 0.0
0 2 3.0 // A[0][2] = 3.0
1 0 3.2 // A[1][0] = 3.2
1 1 0.8 // A[1][1] = 0.8
```

map

```
(0, 1.0)
(0, 0.0)
(0, 3.0)
(1, 3.2)
(1, 0.8)
```

```
1 2 32.0 // A[1][2] = 32.0
2 0 1.0 // A[2][0] = 1.0
2 1 14.0 // A[2][1] = 14.0
2 2 1.0 // A[2][2] = 1.0
```

map

```
(1, 32.0)
(2, 1.0)
(2, 14.0)
(2, 1.0)
```

sort /  
merge

```
(0, {1.0, 0.0, 3.0})
(1, {3.2, 0.8, 32.0})
(2, {1.0, 14.0, 1.0})
```

reduce

```
(0, sqrt(1.0 + 0.0 + 3.0))
(1, sqrt(3.2 + 0.8 + 32.0))
(2, sqrt(1.0 + 14.0 + 1.0))
```

# MapReduce is suitable to ....

## *MapReduce* 合適用於 ....

- 大規模資料集
- **Large Data Set**
- 可拆解
- **Parallelization**
- Text tokenization
- Indexing and Search
- Data mining
- machine learning
- ...

• <http://www.dbms2.com/2008/08/26/known-applications-of-mapreduce/>

• <http://wiki.apache.org/hadoop/PoweredBy>

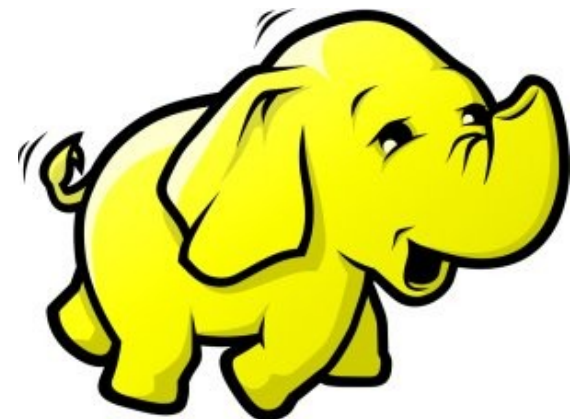




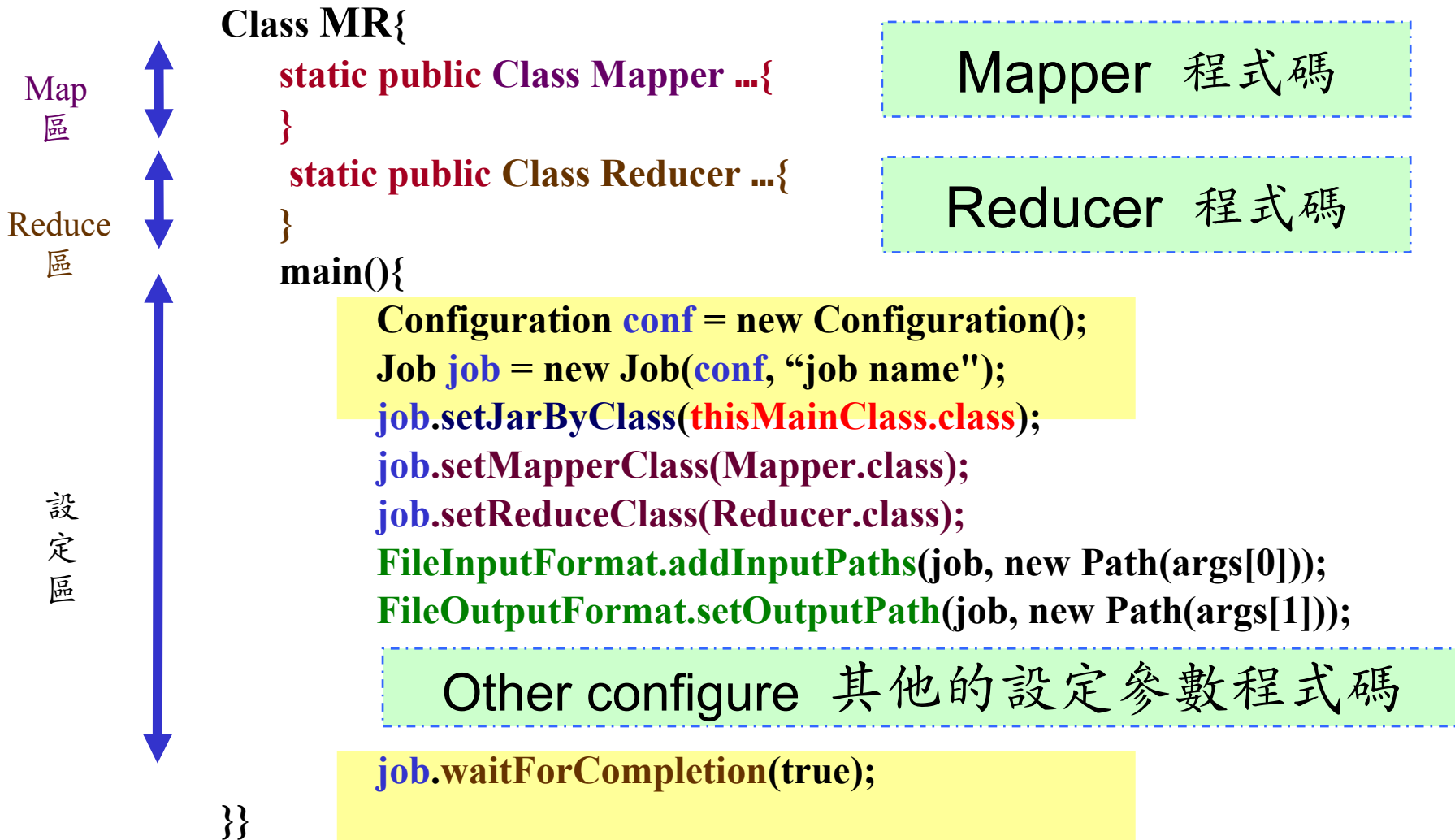
# MapReduce 程式設計入門

## MapReduce Programing 101

**Jazz Wang**  
**Yao-Tsung Wang**  
**jazz@nchc.org.tw**



# Program Prototype (v 0.20)



# Program Prototype (v 0.18)

**Class MR{**

```
static public Class Mapper ...{  
}
```

Map 程式碼

```
static public Class Reducer ...{  
}
```

Reduce 程式碼

```
main(){
```

```
JobConf conf = new JobConf( MR.class );
```

```
conf.setMapperClass(Mapper.class);
```

```
conf.setReduceClass(Reducer.class);
```

```
FileInputFormat.setInputPaths(conf, new Path(args[0]));
```

```
FileOutputFormat.setOutputPath(conf, new Path(args[1]));
```

Other configure 其他的設定參數程式碼

```
JobClient.runJob(conf);
```

```
}
```

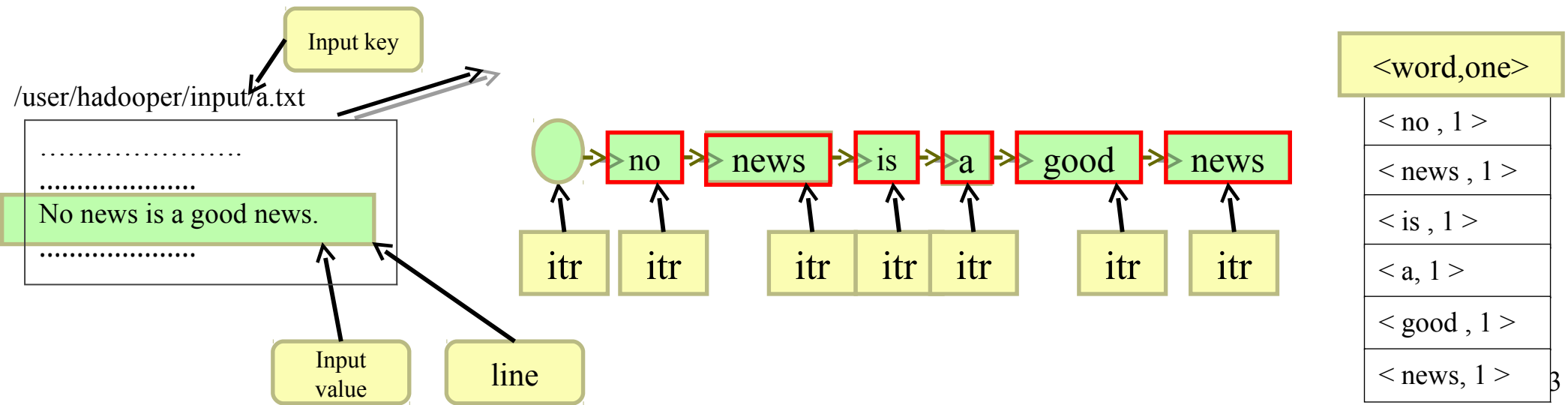
Map  
區

Reduce  
區

設定  
區

# Word Count - mapper

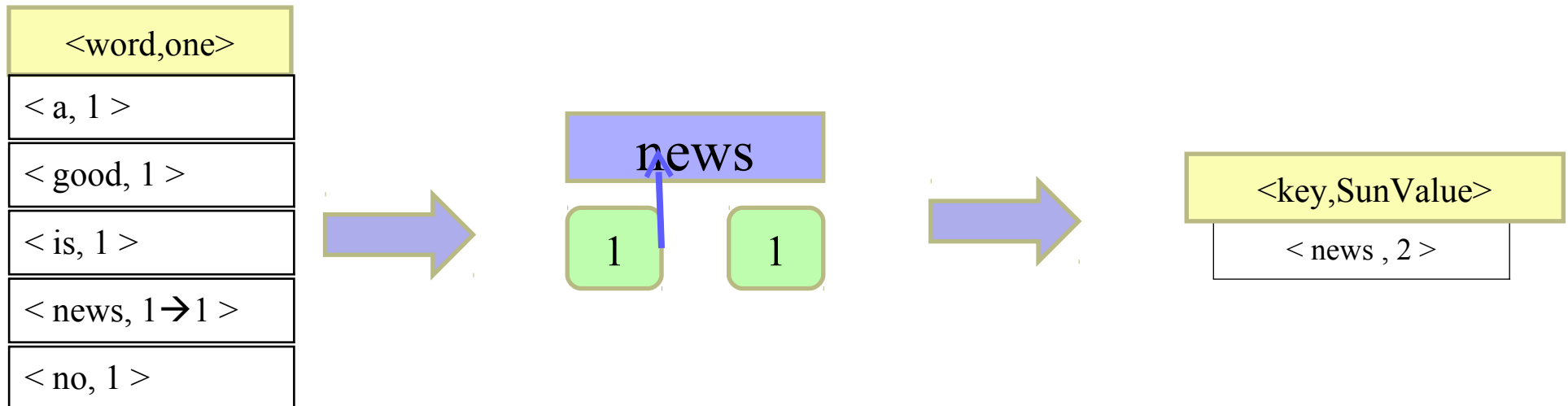
```
1 class MyMapper extends Mapper<LongWritable, Text, Text, IntWritable> {  
2     private final static IntWritable one = new IntWritable(1);  
3     private Text word = new Text();  
4     public void map( LongWritable key, Text value, Context context)  
5         throws IOException , InterruptedException {  
6         String line = ((Text) value).toString();  
7         StringTokenizer itr = new StringTokenizer(line);  
8         while (itr.hasMoreTokens()) {  
9             word.set(itr.nextToken());  
10            context.write(word, one);  
11        }  
12    }  
13 }
```



# Word Count - reducer

```
1 class MyReducer extends Reducer< Text, IntWritable, Text, IntWritable> {  
2     IntWritable result = new IntWritable();  
3     public void reduce( Text key, Iterable <IntWritable> values, Context context)  
4     throws IOException, InterruptedException {  
5         int sum = 0;  
6         for ( IntWritable val : values )  
7         sum += val.get();  
8         result.set(sum);  
         context.write ( key, result);  
    }  
}
```

```
for ( int i ; i < values.length ; i ++ ){  
    sum += values[i].get()  
}
```



# Word Count – main program

```
Class WordCount{
  main()
    Configuration conf = new Configuration();
    Job job = new Job(conf, “job name” );
    job.setJarByClass(thisMainClass.class);
    job.setMapperClass(MyMapper.class);
    job.setReducerClass(MyReducer.class);
    FileInputFormat.addInputPaths(job, new Path(args[0]));
    FileOutputFormat.setOutputPath(job, new Path(args[1]));
    job.waitForCompletion(true);
}
```



## Questions?

Slides - <http://trac.nchc.org.tw/cloud>

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**jazz@nchc.org.tw**



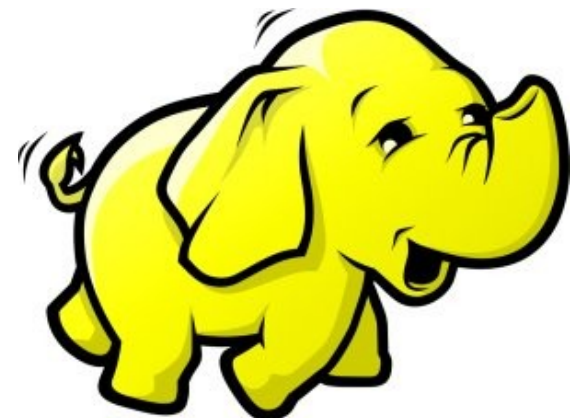
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# Hadoop 相關計畫

## Hadoop Ecosystem

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**Yao-Tsung Wang**  
**[jazz@nchc.org.tw](mailto:jazz@nchc.org.tw)**







**Hadoop** 只支援用 **Java** 開發嘛？  
**Is Hadoop only support Java ?**

總不能全部都重新設計吧？如何與舊系統相容？

**Can Hadoop work with existing software ?**

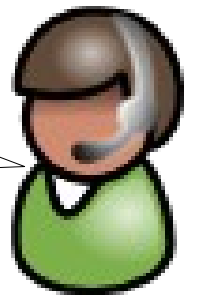


可以跟資料庫結合嘛？

**Can Hadoop work with Databases ?**

開發者們有聽到大家的需求 .....

**Yes, we hear the feedback of developers ...**



# Is Hadoop only support Java ?

- Although the Hadoop framework is implemented in Java<sup>™</sup>, **Map/Reduce applications need not be written in Java.**
- **Hadoop Streaming** is a utility which allows users to **create and run jobs with any executables (e.g. shell utilities)** as the mapper and/or the reducer.
- **Hadoop Pipes** is a SWIG-compatible **C++ API** to implement Map/Reduce applications (non JNI<sup>™</sup> based).

# Hadoop Pipes (C++, Python)

- Hadoop Pipes allows **C++** code to use Hadoop DFS and map/reduce.
- The C++ interface is "swigable" so that interfaces can be generated for **python** and other scripting languages.
- For more detail, check the API Document of [org.apache.hadoop.mapred.pipes](http://org.apache.hadoop.mapred.pipes)
- You can also find example code at [hadoop-\\*/src/examples/pipes](http://hadoop-*/src/examples/pipes)
- About the pipes C++ WordCount example code: <http://wiki.apache.org/hadoop/C++WordCount>

# Hadoop Streaming

- Hadoop Streaming is a utility which allows users to create and run Map-Reduce jobs **with any executables (e.g. Unix shell utilities)** as the mapper and/or the reducer.
- It's useful when you need to run **existing program** written in shell script, perl script or even PHP.
- Note: both the **mapper** and the **reducer** are **executables** that read the input from **STDIN** (line by line) and emit the output to **STDOUT**.
- For more detail, check the official document of **Hadoop Streaming**

# Running Hadoop Streaming

```
jazz@hadoop:~$ hadoop jar hadoop-streaming.jar -help
```

```
10/08/11 00:20:00 ERROR streaming.StreamJob: Missing required option -input
```

```
Usage: $HADOOP_HOME/bin/hadoop [--config dir] jar \  
      $HADOOP_HOME/hadoop-streaming.jar [options]
```

Options:

```
-input      <path>      DFS input file(s) for the Map step  
-output    <path>      DFS output directory for the Reduce step  
-mapper    <cmd|JavaClassName>      The streaming command to run  
-combiner <JavaClassName> Combiner has to be a Java class  
-reducer   <cmd|JavaClassName>      The streaming command to run  
-file      <file>      File/dir to be shipped in the Job jar file  
-dfs       <h:p>|local Optional. Override DFS configuration  
-jt        <h:p>|local Optional. Override JobTracker configuration  
-additionalconfspec specfile Optional.  
-inputformat TextInputFormat (default) |SequenceFileAsTextInputFormat |  
JavaClassName Optional.  
-outputformat TextOutputFormat (default) |JavaClassName Optional.
```

... More ...

# Hadoop Streaming with shell commands (1)

```
hadoop:~$ hadoop fs -rmr input output
```

```
hadoop:~$ hadoop fs -put /etc/hadoop/conf input
```

```
hadoop:~$ hadoop jar hadoop-streaming.jar -input  
input -output output -mapper /bin/cat  
-reducer /usr/bin/wc
```

# Hadoop Streaming with shell commands (2)

```
hadoop:~$ echo "sed -e \"s/ /\n/g\" | grep ." >  
streamingMapper.sh
```

```
hadoop:~$ echo "uniq -c | awk '{print \$2 \"\t\"  
\$1}'" > streamingReducer.sh
```

```
hadoop:~$ chmod a+x streamingMapper.sh
```

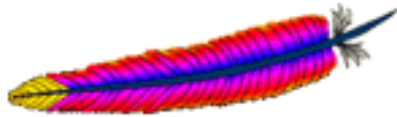
```
hadoop:~$ chmod a+x streamingReducer.sh
```

```
hadoop:~$ hadoop fs -put /etc/hadoop/conf input
```

```
hadoop:~$ hadoop jar hadoop-streaming.jar -input  
input -output output -mapper streamingMapper.sh  
-reducer streamingReducer.sh -file  
streamingMapper.sh -file streamingReducer.sh
```

# There are several Hadoop subprojects

Apache > Hadoop >



Top

Common

Chukwa

HBase

HDFS

Hive

MapReduce

Pig

ZooKeeper

▼ About

▫ Welcome

▫ Who We Are?

▫ Mailing Lists

## Welcome to Apache Hadoop!

- **Hadoop Common:** The common utilities that support the other Hadoop subprojects.
- **HDFS:** A distributed file system that provides high throughput access to application data.
- **MapReduce:** A software framework for distributed processing of large data sets on compute clusters.



## Other Hadoop related projects

- **Chukwa**: A data collection system for managing large distributed systems.
- **HBase**: A scalable, distributed database that supports structured data storage for large tables.
- **Hive**: A data warehouse infrastructure that provides data summarization and ad hoc querying.
- **Pig**: A high-level data-flow language and execution framework for parallel computation.
- **ZooKeeper**: A high-performance coordination service for distributed applications.

# Hadoop Ecosystem

<b>Pig</b>	<b>Chukwa</b>	<b>Hive</b>	<b>HBase</b>
<b>MapReduce</b>		<b>HDFS</b>	<b>ZooKeeper</b>
<b>Hadoop Core (Hadoop Common)</b>		<b>Avro</b>	

Source: *Hadoop: The Definitive Guide*

# Avro

- Avro is a **data serialization system**.
- It provides:
  - *Rich data structures.*
  - *A compact, fast, binary data format.*
  - *A container file, to store persistent data.*
  - *Remote procedure call (RPC).*
  - *Simple integration with dynamic languages.*
- Code generation is not required to read or write data files nor to use or implement RPC protocols. Code generation as an optional optimization, only worth implementing for statically typed languages.
- For more detail, please check the official document:  
<http://avro.apache.org/docs/current/>



# Zoo Keeper



- <http://hadoop.apache.org/zookeeper/>
- ZooKeeper is a **centralized service** for **maintaining configuration** information, **naming**, **providing distributed synchronization**, and providing group services. All of these kinds of services are used in some form or another by distributed applications.
- *Each time they are implemented there is a lot of work that goes into fixing the bugs and **race conditions** that are inevitable. Because of the difficulty of implementing these kinds of services, applications initially usually skimp on them, which make them brittle in the presence of change and difficult to manage. Even when done correctly, different implementations of these services lead to management complexity when the applications are deployed.*

# Pig

- <http://hadoop.apache.org/pig/>
- Pig is a platform for **analyzing large data sets** that consists of a **high-level language** for expressing data analysis programs, coupled with infrastructure for evaluating these programs.
- Pig's infrastructure layer consists of a **compiler** that produces sequences of **Map-Reduce programs**
- Pig's language layer currently consists of a textual language called **Pig Latin**, which has the following key properties:
  - **Ease of programming**
  - **Optimization opportunities**
  - **Extensibility**



# Hive

- <http://hadoop.apache.org/hive/>
- Hive is a **data warehouse** infrastructure built on top of Hadoop that provides tools to enable easy **data summarization**, **adhoc querying** and analysis of large datasets data stored in Hadoop files.
- **Hive QL** is based on SQL and enables users familiar with SQL to query this data.



# Chukwa

- <http://hadoop.apache.org/chukwa/>
- Chukwa is an open source **data collection system** for monitoring large distributed systems.
- built on top of HDFS and Map/Reduce framework
- includes a flexible and powerful toolkit for displaying, monitoring and analyzing results to make the best use of the collected data.



# Mahout

- <http://mahout.apache.org/>
- Mahout is a scalable **machine learning libraries**.
- implemented on top of Apache Hadoop using the map/reduce paradigm.
- Mahout currently has
  - Collaborative Filtering
  - User and Item based recommenders
  - **K-Means, Fuzzy K-Means clustering**
  - Mean Shift clustering
  - More ...



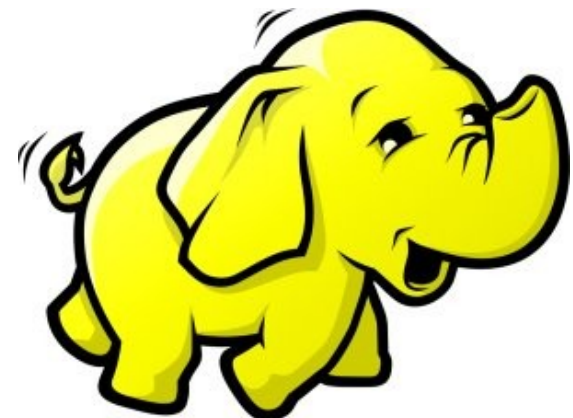




# HBase 雲端資料庫

Introduction to HBase

**Jazz Wang**  
**Yao-Tsung Wang**  
**[jazz@nchc.org.tw](mailto:jazz@nchc.org.tw)**



# It's all about SCALE!!



**Warning:** fopen(/home/dodgers/public\_html/./logs/oracle\_error\_log.txt) [function.fopen]: failed to open stream: Permission denied in /usr/local/apache/htdocs/include2007/oracle/db\_oracle.inc.php on line 194

Cannot open Database Error Log, please check!! (/home/dodgers/public\_html/./logs/oracle\_error\_log.txt)

**Warning:** fopen(/home/dodgers/public\_html/./logs/oracle\_error\_log.txt) [function.fopen]: failed to open stream: Permission denied in /usr/local/apache/htdocs/include2007/oracle/db\_oracle.inc.php on line 194

Cannot open Database Error Log, please check!! (/home/dodgers/public\_html/./logs/oracle\_error\_log.txt)

**Warning:** fopen(/home/dodgers/public\_html/./logs/oracle\_error\_log.txt) [function.fopen]: failed to open stream: Permission denied in /usr/local/apache/htdocs/include2007/oracle/db\_oracle.inc.php on line 194

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Cannot open Database Error Log, please check!! (/home/dodgers/public\_html/./logs/oracle\_error\_log.txt)



訂購歷史紀錄

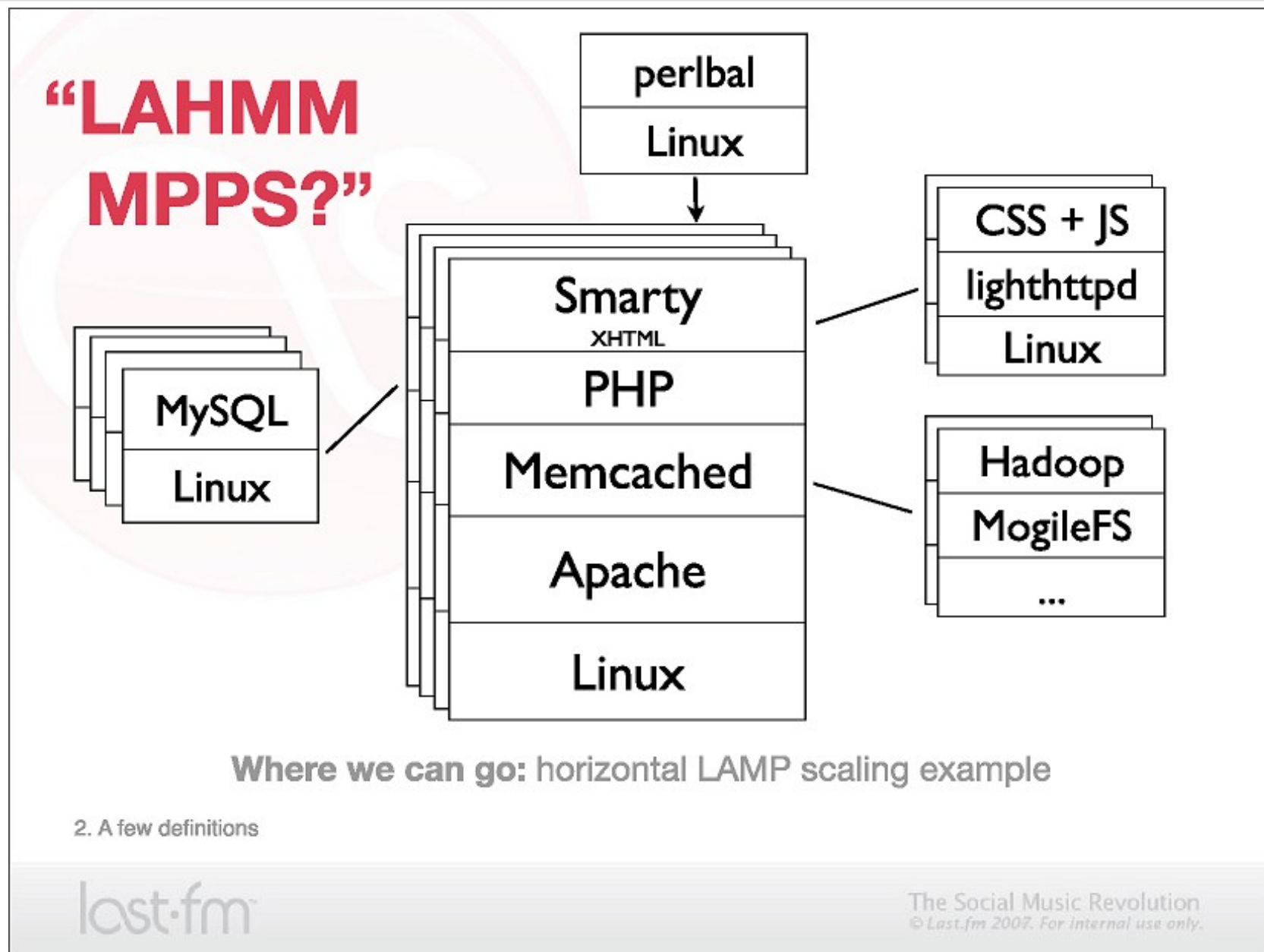


denied in /usr/local/apache/htdocs/include2007/oracle/db\_oracle.inc.php on line 194

Cannot open Database Error Log, please check!! (/home/dodgers/public\_html/./logs/oracle\_error\_log.txt)

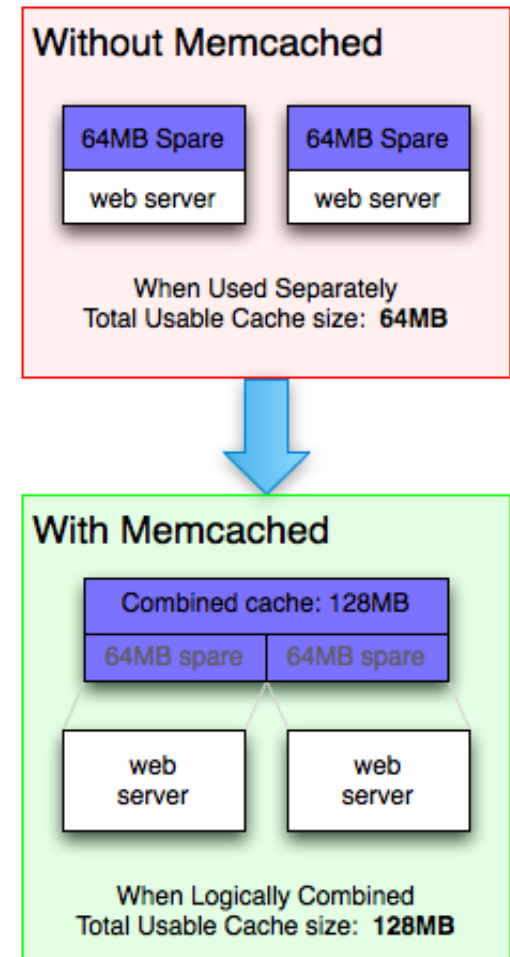
**Warning:** fopen(/home/dodgers/public\_html/./logs/oracle\_error\_log.txt) [function.fopen]: failed to open stream: Permission

# How to scale up web service in the past ?



# Tools used by large scale websites

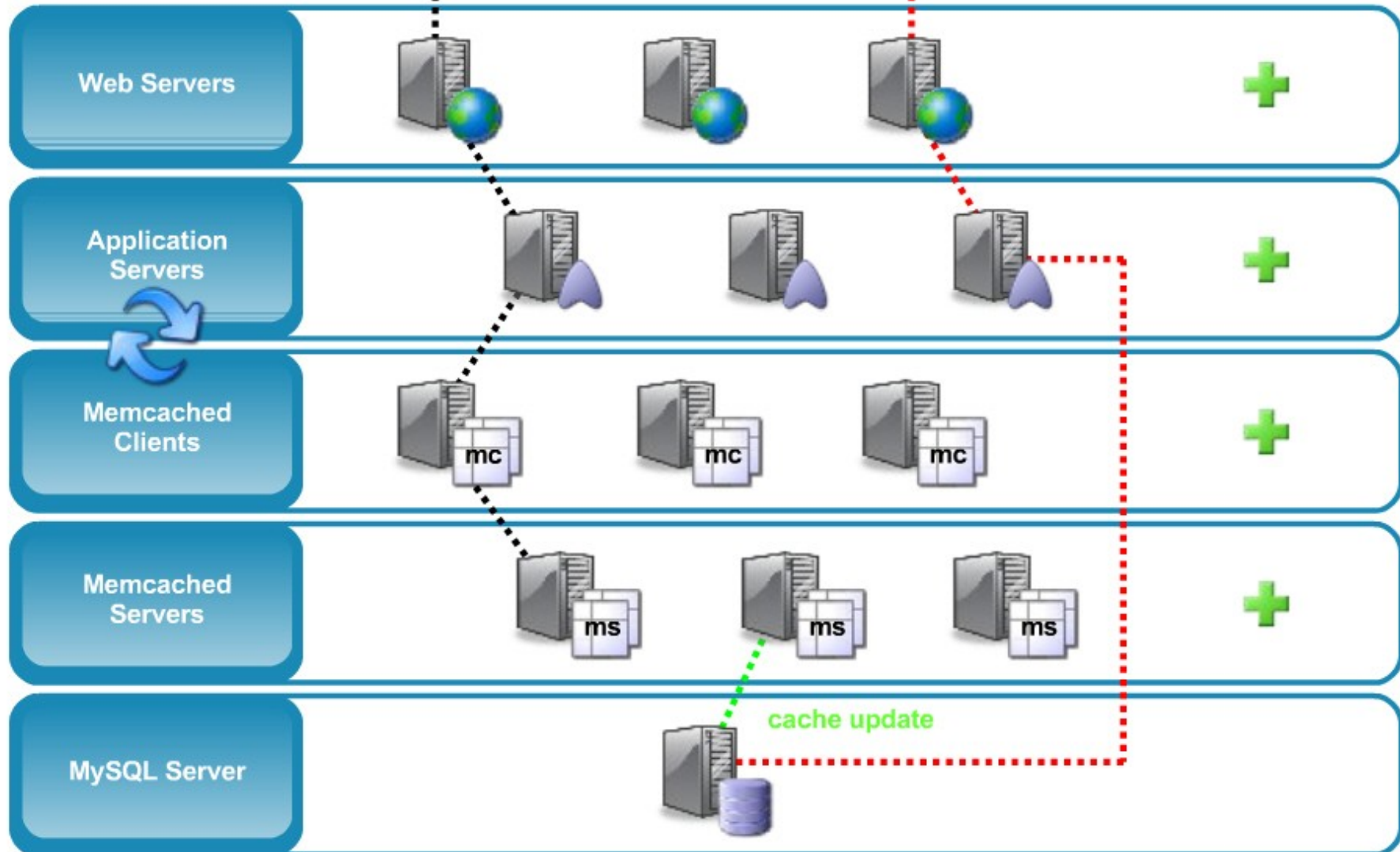
- Perlbal - <http://www.danga.com/perlbal/>
  - ◆ 多個網頁伺服器的負載平衡
  - ◆ Load balancer
- MogileFS - <http://www.danga.com/mogilefs/>
  - ◆ 分散式檔案系統
  - ◆ Distributed File System for small files
  - ◆ 有公司認為 MogileFS 比起 Hadoop 適合拿來處理小檔案
- memcached - <http://memcached.org/>
  - ◆ 共享記憶體 ??
  - ◆ Share Memory
  - ◆ 把資料庫或經常讀取的部分，用記憶體快取 (Cache) 方式存放
- Moxi - <http://code.google.com/p/moxi/>
  - ◆ Memcache 的 PROXY
- More Resource:
  - ◆ <http://code.google.com/p/memcached/wiki/HowToLearnMoreScalability>
  - ◆ <http://www.slideshare.net/techdude/scalable-web-architectures-common-patterns-and-approaches>



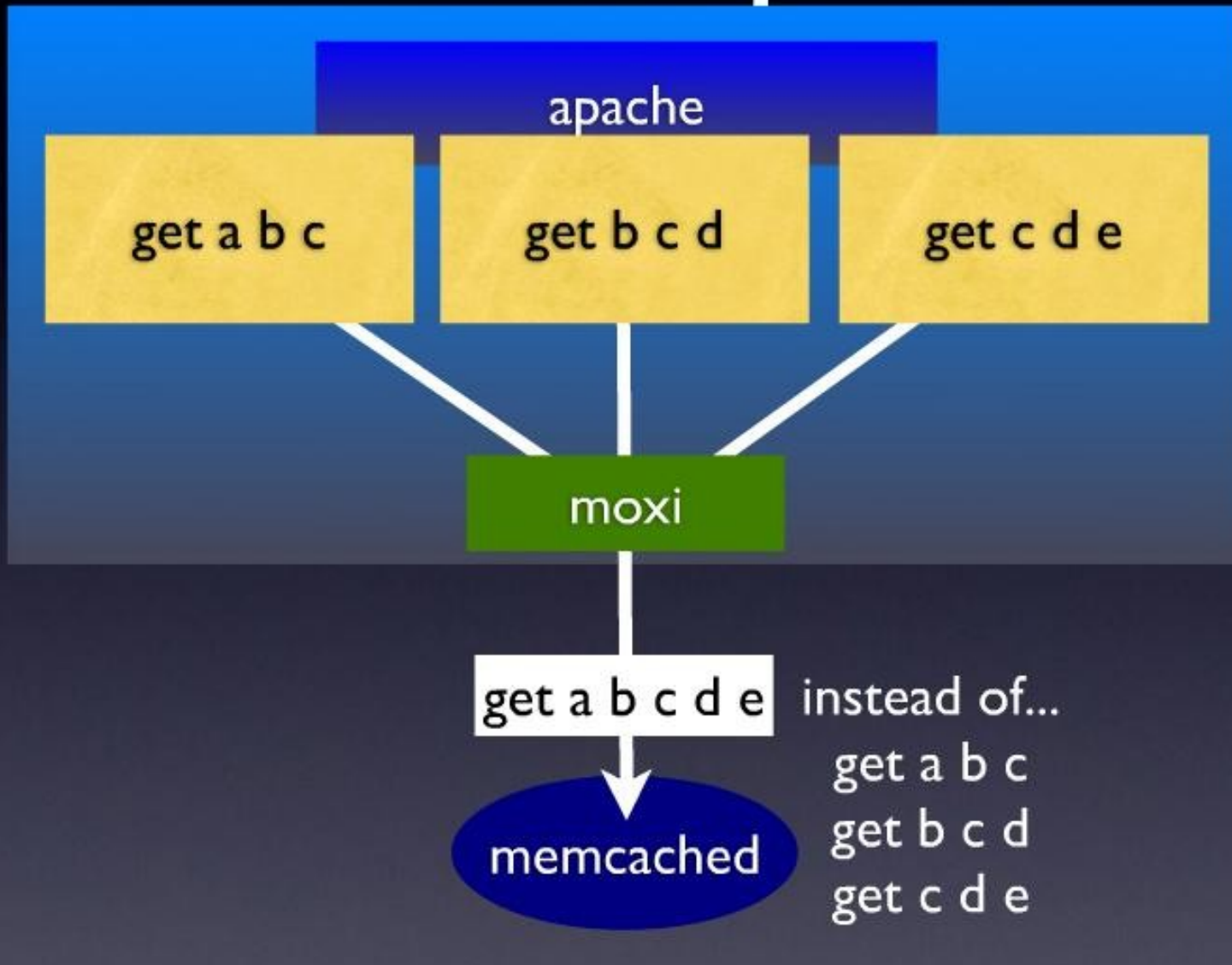
# Memcached & MySQL

read

write

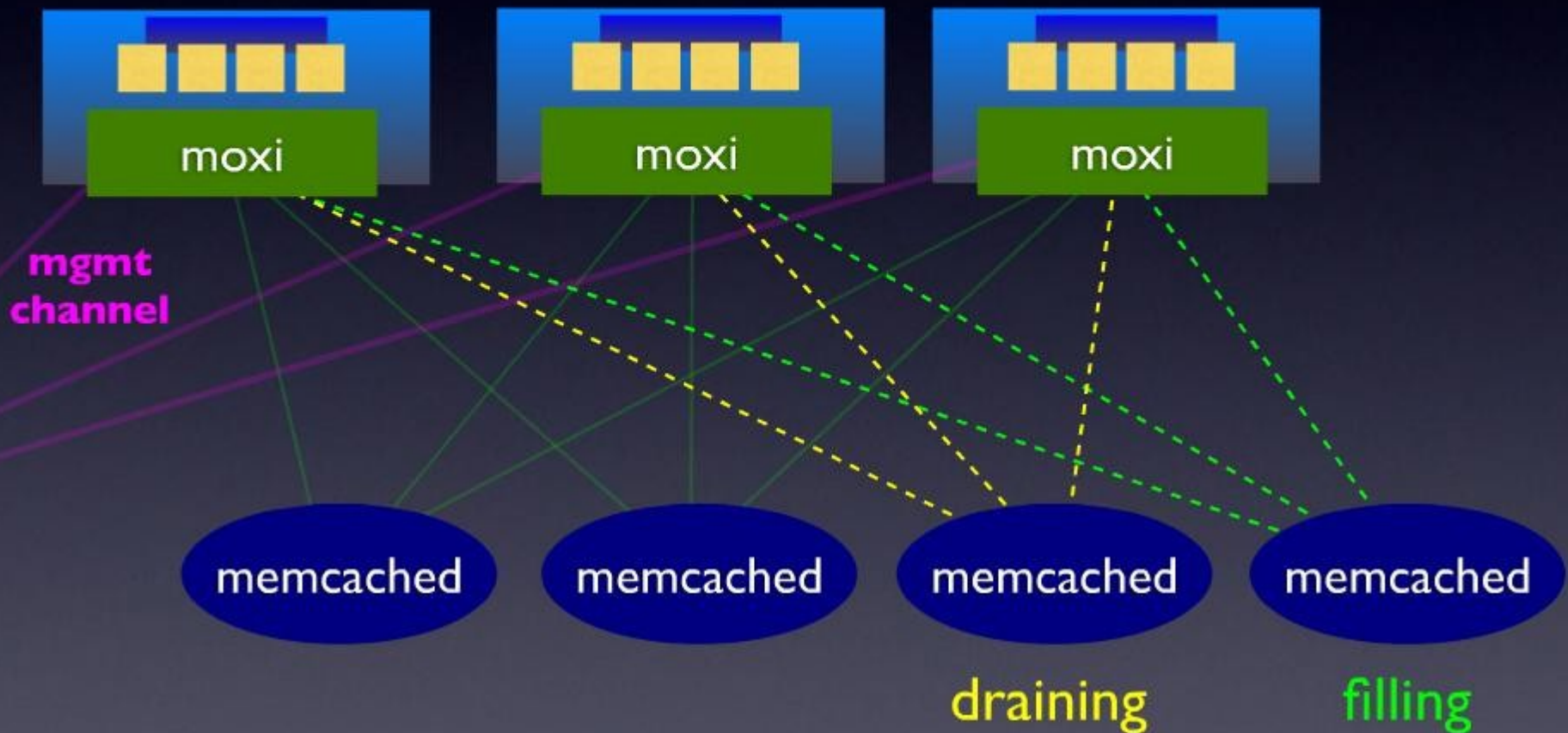


# GET de-duplication



# draining and filling

lazily migrate items from old server to new server



# HBase is ..

- HBase is a distributed **column-oriented database** built on top of HDFS.
- A distributed data store that can scale horizontally to 1,000s of commodity servers and **petabytes** of indexed storage.
- Designed to operate on top of the Hadoop distributed file system (**HDFS**) or Kosmos File System (**KFS**, aka Cloudstore) for scalability, fault tolerance, and high availability.
- Integrated into the Hadoop **map-reduce** platform and paradigm.



# Benefits

- Distributed storage
- Table-like in data structure
  - multi-dimensional map
- High scalability
- High availability
- High performance

# Who use HBase

- Adobe
  - 內部使用 (Structure data)
- Kalooga
  - 圖片搜尋引擎 <http://www.kalooga.com/>
- Meetup
  - 社群聚會網站 <http://www.meetup.com/>
- Streamy
  - Migrate from MySQL to Hbase <http://www.streamy.com/>
- Trend Micro
  - 雲端掃毒架構 <http://trendmicro.com/>
- Yahoo!
  - 儲存文件 fingerprint 避免重複 <http://www.yahoo.com/>
- More - <http://wiki.apache.org/hadoop/Hbase/PoweredBy>

# Backdrop

- Started toward by Chad Walters and Jim
- 2006.11
  - Google releases paper on **BigTable**
- 2007.2
  - Initial HBase prototype created as Hadoop contrib.
- 2007.10
  - First useable HBase
- 2008.1
  - Hadoop become Apache top-level project and HBase becomes subproject
- 2008.10~
  - HBase 0.18, 0.19 released

# HBase Is Not ...

- Tables have **one primary index**, the *row key*.
- **No join operators.**
- Scans and queries can select a subset of available columns, perhaps by using a wildcard.
- There are three types of lookups:
  - Fast lookup using row key and optional timestamp.
  - Full table scan
  - Range scan from region start to end.

# HBase Is Not ... (2)

- Limited atomicity and transaction support.
  - HBase supports **multiple batched mutations of single rows** only.
  - Data is unstructured and untyped.
- No accessed or manipulated via SQL.
  - Programmatic access via Java, REST, or **Thrift APIs**.
  - Scripting via JRuby.

# Why Bigtable?

- Performance of RDBMS system is good for transaction processing but for very large scale analytic processing, the solutions are commercial, expensive, and specialized.
- Very large scale analytic processing
  - Big queries – typically range or table scans.
  - **Big databases (100s of TB)**

## Why Bigtable? (2)

- Map reduce on Bigtable with optionally Cascading on top to support some relational algebras may be a cost effective solution.
- Sharding is not a solution to scale open source RDBMS platforms
  - Application specific
  - Labor intensive (re)partitionaing

# Why HBase ?

- HBase is a Bigtable clone.
- It is open source
- It has a good community and promise for the future
- It is developed on top of and has good integration for the Hadoop platform, if you are using Hadoop already.
- It has a Cascading connector.

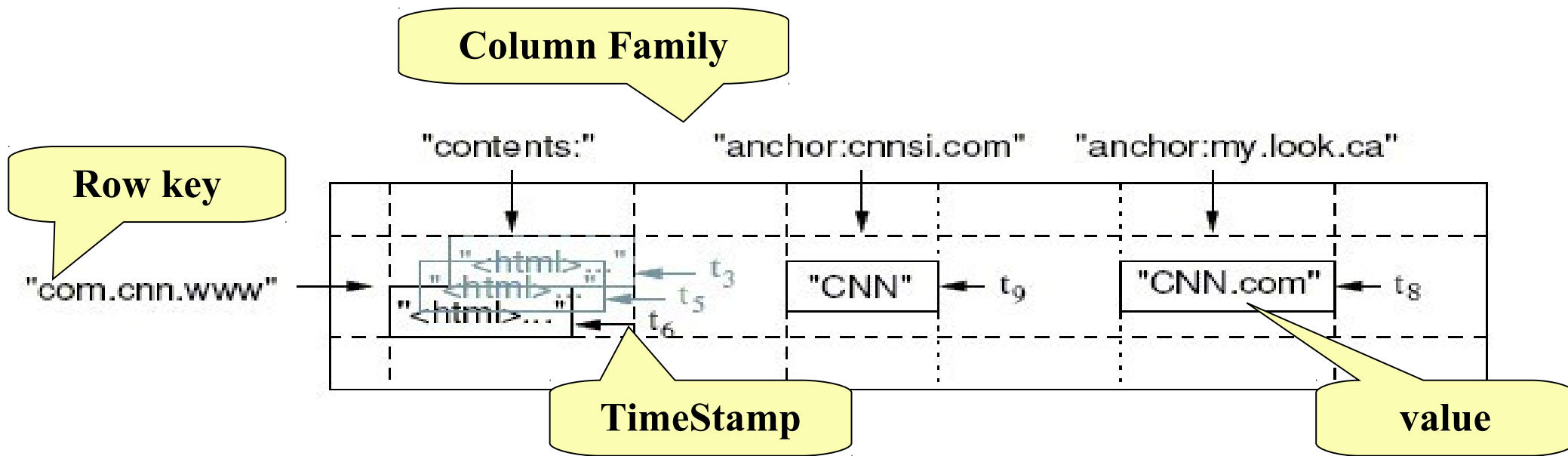


# HBase benefits than RDBMS

- *No real indexes*
- *Automatic partitioning*
- *Scale linearly and automatically* with new nodes
- *Commodity hardware*
- *Fault tolerance*
- *Batch processing*

# Data Model

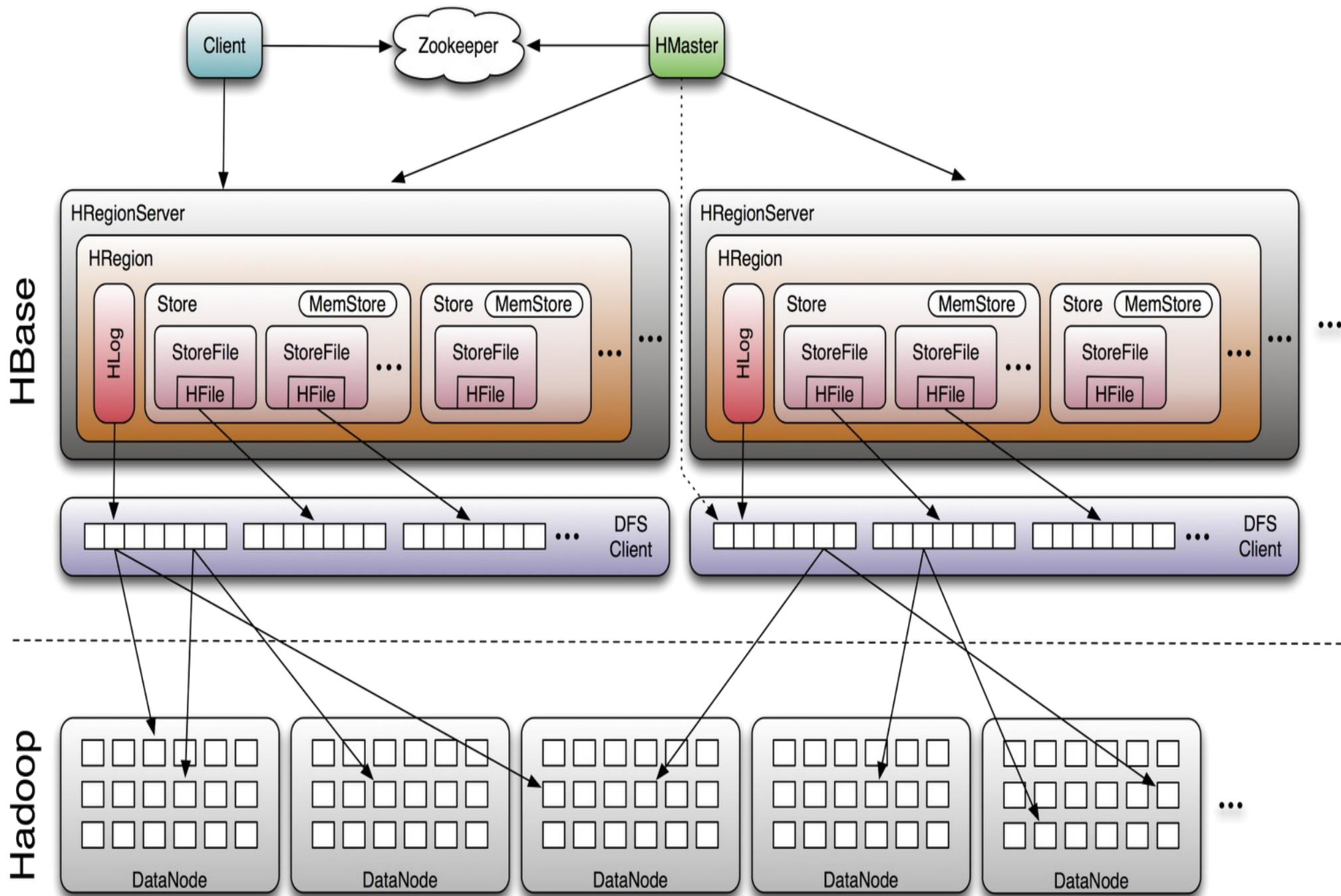
- Tables are sorted by **Row**
- Table schema only define it's *column families*.
  - Each family consists of any number of columns
  - Each column consists of any number of versions
  - Columns only exist when inserted, NULLs are free.
  - Columns within a family are sorted and stored together
- Everything except table names are byte[]
- **(Row, Family: Column, Timestamp) → Value**



# Members

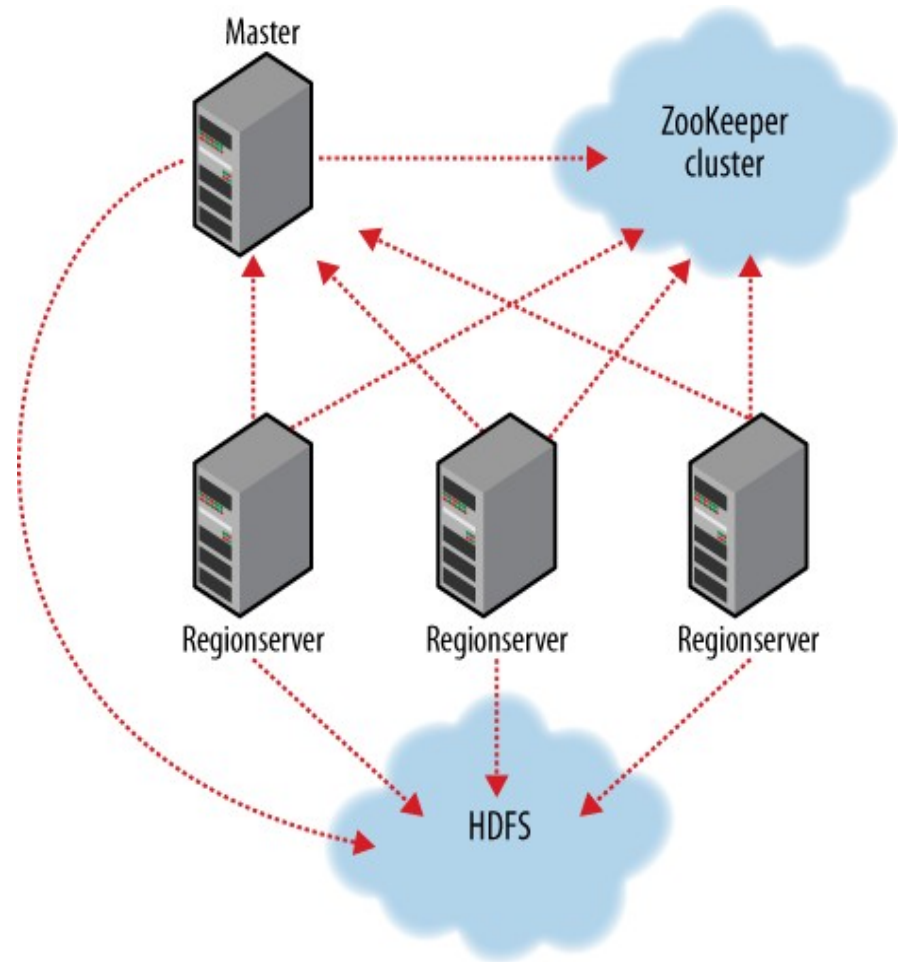
- *Master*
  - Responsible for monitoring region servers
  - Load balancing for regions
  - Redirect client to correct region servers
  - The current SPOF
- *regionserver slaves*
  - Serving requests(Write/Read/Scan) of Client
  - Send HeartBeat to Master
  - Throughput and Region numbers are scalable by region servers

# Architecture



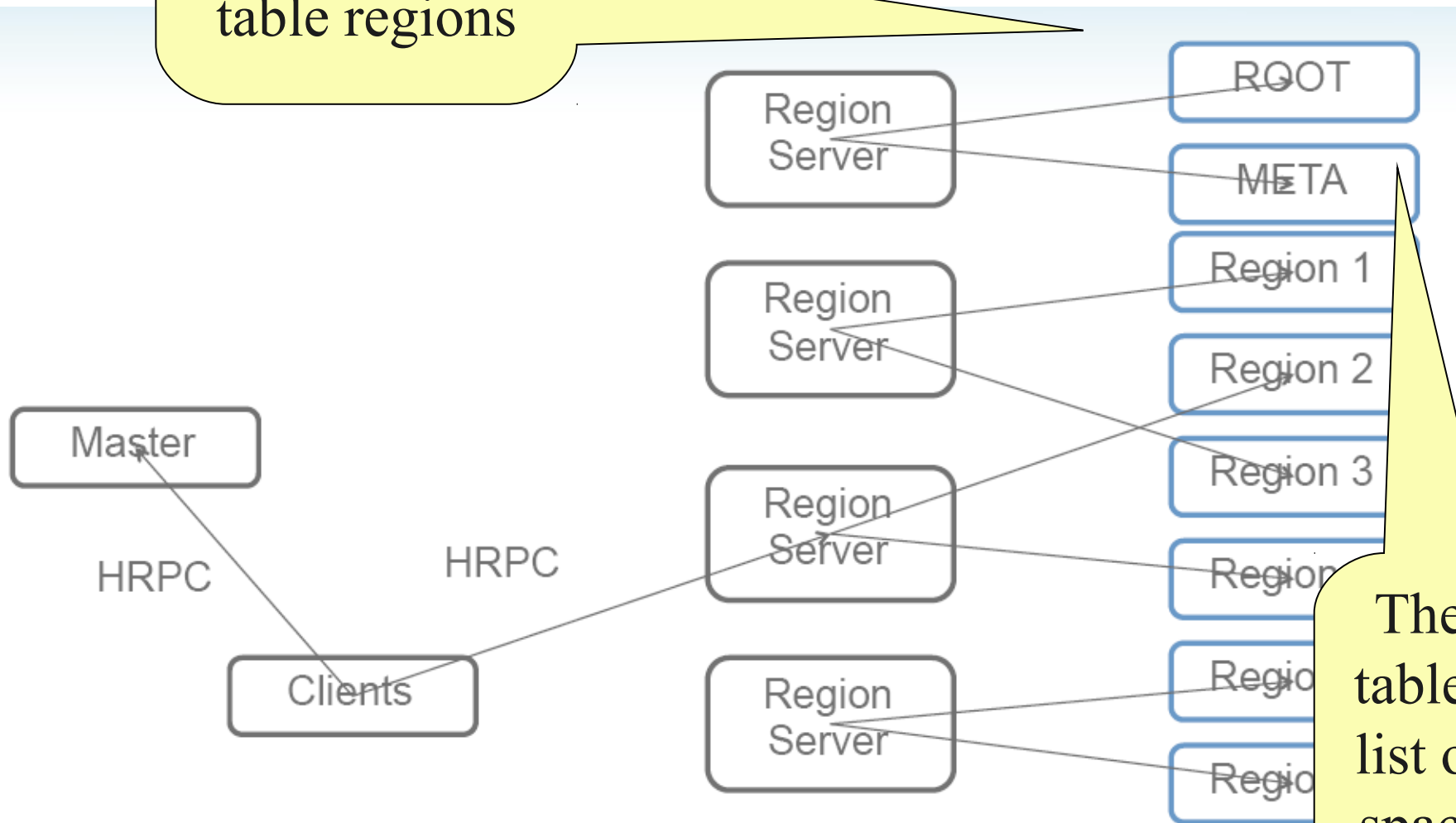
# ZooKeeper

- HBase depends on ZooKeeper (Chapter 13) and by default it manages a ZooKeeper instance as the authority on cluster state



# Operation

The `-ROOT-` table holds the list of `.META.` table regions



The `.META.` table holds the list of all user-space regions.



## Questions?

Slides - <http://trac.nchc.org.tw/cloud>

**Jazz Wang**  
**Yao-Tsung Wang**  
**jazz@nchc.org.tw**



Powered by DRBL

# Introduction to Pig programming



**Yahoo Search Engineering**

陳奕瑋 ( Yiwei Chen )





# 任務！

[殺很大、插很大\(+瑤瑤寫真性感精選54P\) @ osaki's Blog :: Xuite日誌](#)

殺不用錢～殺online瑤瑤性感變裝照+精選性感寫真童顏巨乳的娃娃音美少女瑤瑤 本名：郭書瑤  
暱稱：瑤瑤 身高：155cm 體重：42kg 三圍：33E/23/33 生日：1990/7/18 ...  
[blog.xuite.net/osaki99/blog/21865265](http://blog.xuite.net/osaki99/blog/21865265) - [頁庫存檔](#) - [類似內容](#)

[電玩美少女瑤瑤精選影音\(ヤオヤオ童顏Fカップ爆乳美少女映画videos ...](#)

2008年8月31日 ... 18歲電玩少女瑤瑤半工半讀扛家計 (內有瑤瑤男友) <http://blog.xuite.net/kaiger/daily/23136438> ... 20080913 我猜嗲嗲美少女第二段2號Kiki 3號瑤瑤 ...  
[blog.xuite.net/kaiger/daily/19128818](http://blog.xuite.net/kaiger/daily/19128818) - [頁庫存檔](#) - [類似內容](#)

[+](#) [顯示更多來自 blog.xuite.net 的結果](#)

[jays1943 分享正妹NO.24 無名瑤瑤- 樂多日誌](#)

瑤瑤也沒有哪裡得罪你們押你們為審麼這樣罵他說害女生生氣我看你們長的很醜吧不要自以為是  
喔死網友還罵人ㄟ死勒你要不要臉瑤瑤可是我的偶像你們最好是向一點 ...  
[blog.roodo.com/jays1943/archives/6850053.html](http://blog.roodo.com/jays1943/archives/6850053.html) - [頁庫存檔](#) - [類似內容](#)



# 任務！

## [瑤瑤航空 - Powered by Discuz!](#)

[瑤瑤航空 - Discuz! Board ...](#) 歡迎VIP旅客-魏如昀加入[瑤瑤航空\(2008-4-7\)](#) 歡迎VIP旅客-賴銘偉加入[瑤瑤航空\(2008-3-13\)](#) ... [瑤瑤家族](#) [瑤瑤在雅虎的第一家族](#) [瑤瑤天空部落格](#) [林佩瑤在天空的部落格](#) [林佩瑤](#) [無名網誌](#) [瑤瑤的新照片都在無名啦!](#) [無不癡齋](#) ...

[www.yaoyaofly.com](#) - [庫存頁面](#) - [更多此站結果](#)

## [瑤瑤喵小屋~ - 無名小站](#)

[瑤瑤喵小屋~ - 無名小站 Blog Album...](#) 最近好煩煩煩，我覺得我的腦容量變小了... 好多事情消化不良 好多念頭讓我無法抉擇 (More.) [goukigouki at 無名小站 at 02:39 PM post | Reply\(27\) |](#) [Trackback\(0\) | prosecute](#) ...

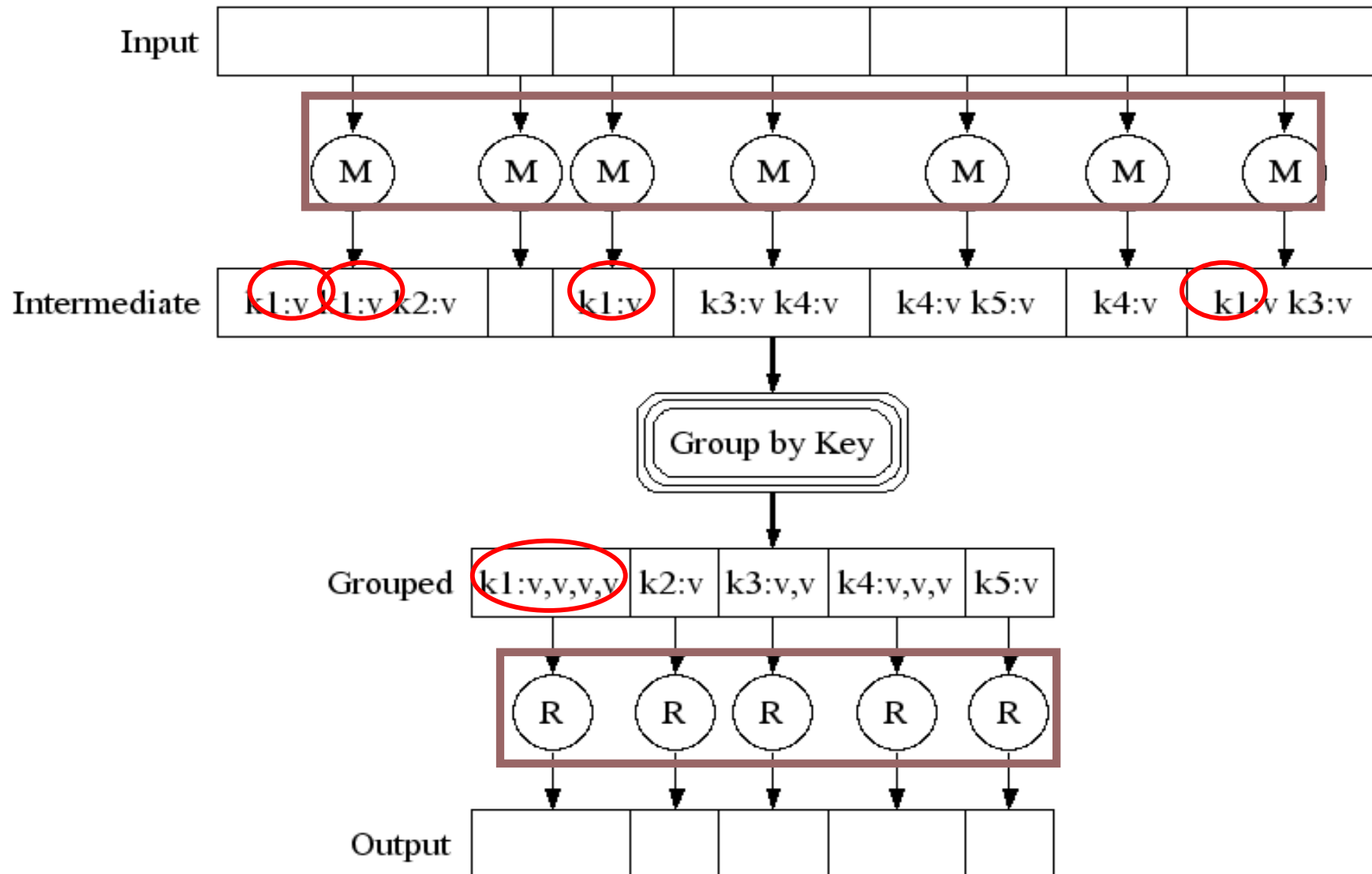
[www.wretch.cc/blog/goukigouki - 74k](#) - [庫存頁面](#) - [更多此站結果](#)



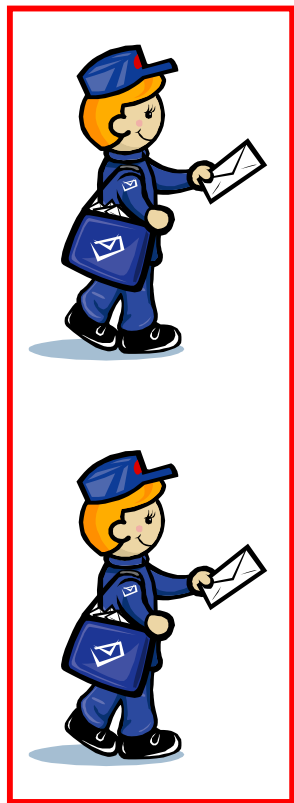
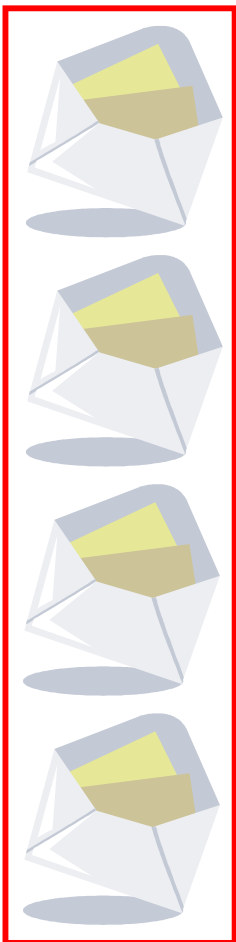
# 任務！

- 你怎麼知道我們放的網頁比較好？
- 你怎麼知道第一筆結果應該要多熱門？

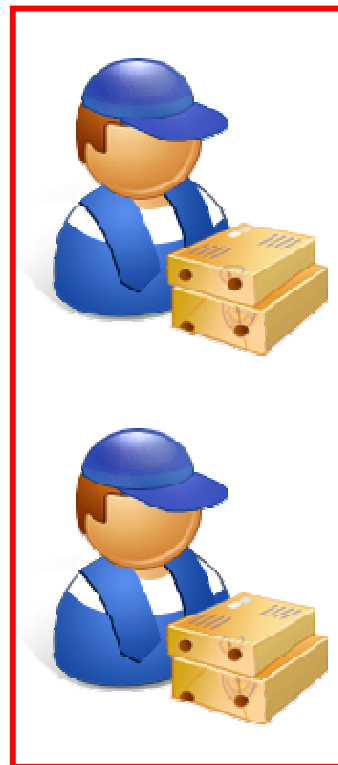
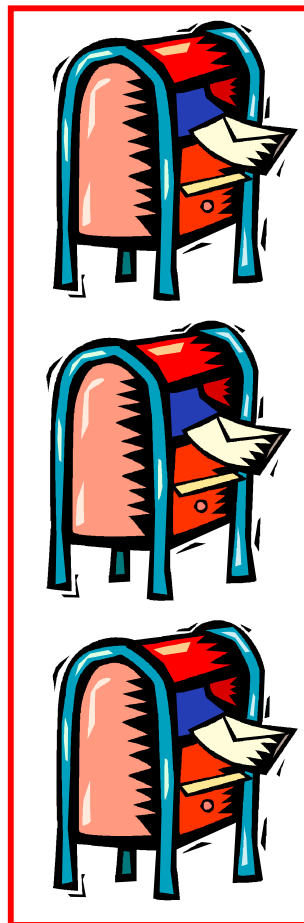
# Hadoop Programming – Map/Reduce



# Map / Reduce



**mappers**



**reducers**



100:  
37



220:  
28

# Map-Reduce

- 全新想法
- 須分別撰寫 mappers & reducers
- 會有超級無敵霹靂多的 mapper/reducer 要維護！

# We usually do ...

- 大部份時候：
  - filtering, projecting
  - grouping, aggregation, joining
- 今天有多少人搜尋「美國生」

# Pig (Latin)

- Procedural dataflow language (Pig Latin) for Map-Reduce
  - 很像 SQL
    - group, join, filter, sort ...
  - 人人都會 SQL



# Pig Script Example

- Top sites visited by users aged 18 to 25

```
Users = LOAD 'users.in' AS (name, age);
Fltrd = FILTER Users by age >= 18 and age <= 25;

Pages = LOAD 'pages.in' AS (user, url);

Jnd    = JOIN Fltrd BY name, Pages BY user;
Grpd   = GROUP Jnd by url;
Smmd   = FOREACH Grpd GENERATE group, COUNT(Jnd) AS
        clicks;

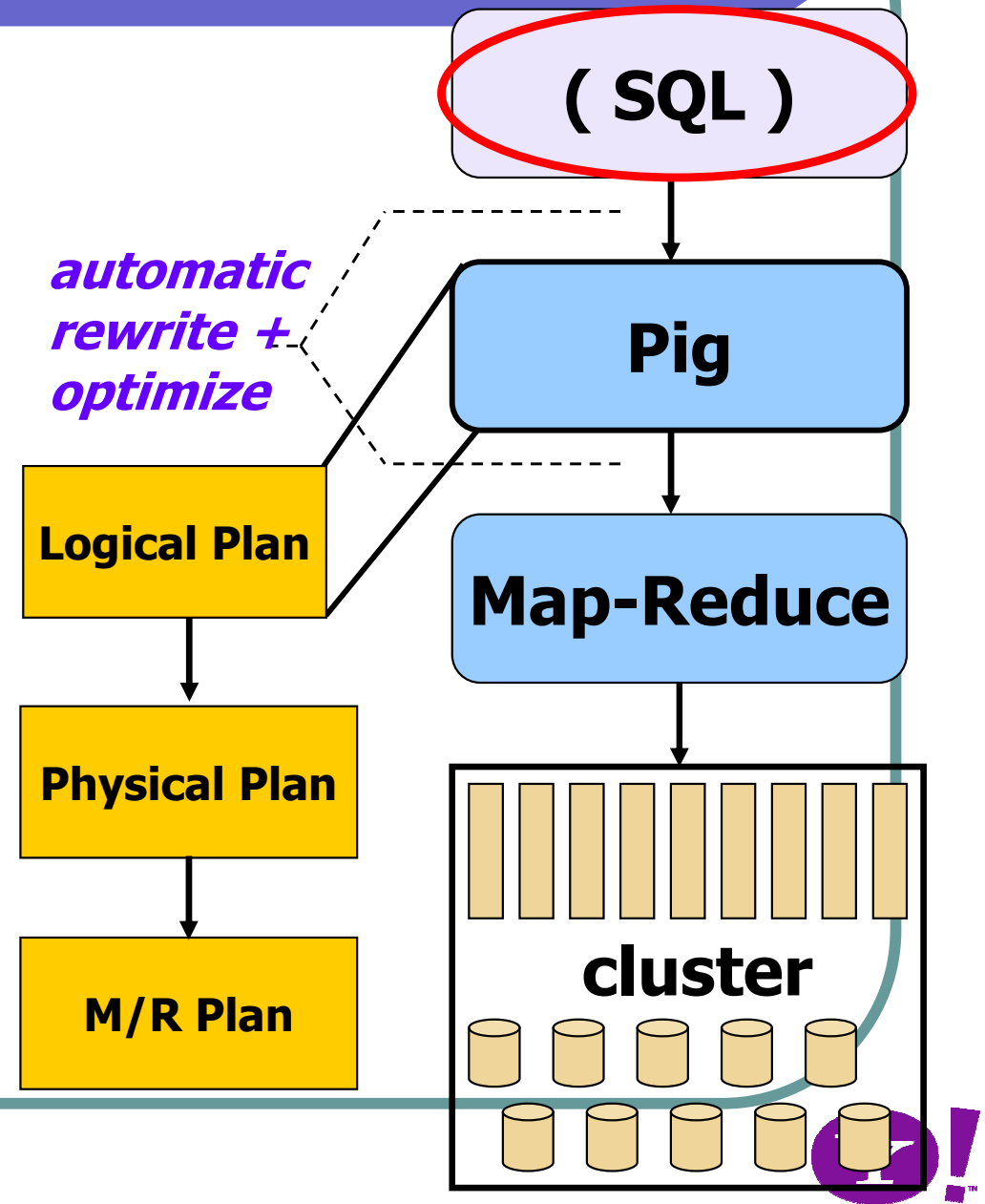
Srttd  = ORDER Smmd BY clicks;
Top100 = LIMIT Srttd 100;

STORE Top100 INTO 'top100sites.out';
```



# Pig script → Map/Reduce

- 不需懂底下 Map-Reduce 運作
- Pig 幫忙翻譯



# Why Pig?

- 容易學
- 開發快
- 一目瞭然

# Why Pig?

```
import java.io.IOException;
import java.util.ArrayList;
import java.util.Iterator;
import java.util.List;

import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.LongWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapred.FileInputFormat;
import org.apache.hadoop.mapred.Mapper;
import org.apache.hadoop.mapred.Mapper2;
import org.apache.hadoop.mapred.MapReduceBase;
import org.apache.hadoop.mapred.RecordReader;
import org.apache.hadoop.mapred.Reducer;
import org.apache.hadoop.mapred.Reporter;
import org.apache.hadoop.mapred.SequenceFileInputFormat;
import org.apache.hadoop.mapred.TextInputFormat;
import org.apache.hadoop.mapred.JobControl;
import org.apache.hadoop.mapred.lib.IdentityMapper;

public class MRExample {
    public static class LoadPages extends MapReduceBase
        implements Mapper<LongWritable, Text, Text, Text> {
        public void map(LongWritable k, Text val,
            OutputCollector<Text, Text> oc,
            Reporter reporter) throws IOException {
            String line = val.toString();
            int firstComma = line.indexOf(',');
            String key = line.substring(0, firstComma);
            String value = line.substring(firstComma + 1);
            Text outKey = new Text(key);
            // Prepend an index to the value so we know which file
            // it came from.
            Text outVal = new Text("1:" + line);
            oc.collect(outKey, outVal);
        }
    }

    public static class LoadAndFilterUsers extends MapReduceBase
        implements Mapper<LongWritable, Text, Text, Text> {
        public void map(LongWritable k, Text val,
            OutputCollector<Text, Text> oc,
            Reporter reporter) throws IOException {
            // Pull the key into a LongWritable(sum));
            String line = val.toString();
            int firstComma = line.indexOf(',');
            String value = line.substring(firstComma + 1);
            int age = Integer.parseInt(value);
            if (age < 18 || age > 25) return;
            String key = line.substring(0, firstComma);
            Text outKey = new Text(key);
            // Prepend an index to the value so we know which file
            // it came from.
            Text outVal = new Text("2:" + value);
            oc.collect(outKey, outVal);
        }
    }

    public static class Join extends MapReduceBase
        implements Reducer<Text, Text, Text, Text> {
        public void reduce(Text key,
            Iterator<Text> iter,
            OutputCollector<Text, Text> oc,
            Reporter reporter) throws IOException {
            // For each value, figure out which file it's from and
            // accordingly.
            List<String> first = new ArrayList<String>();
            List<String> second = new ArrayList<String>();

            while (iter.hasNext()) {
                Text t = iter.next();
                String value = t.toString();
            }
        }
    }

    public static class LoadJoined extends MapReduceBase
        implements Mapper<Text, Text, Text, LongWritable> {
        public void map(
            Text key,
            Text val,
            OutputCollector<Text, LongWritable> oc,
            Reporter reporter) throws IOException {
            // Find the url
            String line = val.toString();
            int firstComma = line.indexOf(',');
            int secondComma = line.indexOf(',', firstComma);
            String key = line.substring(firstComma, secondComma);
            String value = line.substring(secondComma + 1);
            Text outKey = new Text(key);
            oc.collect(outKey, new LongWritable(1L));
        }
    }

    public static class ReduceUrls extends MapReduceBase
        implements Reducer<Text, LongWritable, WritableComparable,
            Writable> {
        public void map(
            WritableComparable key,
            Writable val,
            OutputCollector<LongWritable, Text> oc,
            Reporter reporter) throws IOException {
            long sum = 0;
            while (iter.hasNext()) {
                sum += iter.next().get();
                reporter.setStatus("OK");
            }
        }
    }

    public static class LoadClicks extends MapReduceBase
        implements Mapper<WritableComparable, Writable, LongWritable,
            Text> {
        public void map(
            WritableComparable key,
            Writable val,
            OutputCollector<LongWritable, Text> oc,
            Reporter reporter) throws IOException {
            int count = 0;
            public void reduce(
                LongWritable key,
                Iterator<Text> iter,
                OutputCollector<LongWritable, Text> oc,
                Reporter reporter) throws IOException {
                // Only output the first 100 records
                while (count < 100 && iter.hasNext()) {
                    oc.collect(key, iter.next());
                    count++;
                }
            }
        }
    }

    public static class LimitClicks extends MapReduceBase
        implements Reducer<LongWritable, Text, LongWritable, Text> {
        int count = 0;
        public void reduce(
            LongWritable key,
            Iterator<Text> iter,
            OutputCollector<LongWritable, Text> oc,
            Reporter reporter) throws IOException {
            // Only output the first 100 records
            while (count < 100 && iter.hasNext()) {
                oc.collect(key, iter.next());
                count++;
            }
        }
    }

    public static void main(String[] args) {
        JobConf jp = new JobConf(MRExample.class);
        jp.setJobName("Load Pages");
        jp.setInputFormat(TextInputFormat.class);
        jp.setOutputKeyClass(Text.class);
        jp.setOutputValueClass(Text.class);
        FileInputFormat.addInputPath(jp, Path("user/gates/pages"));
        FileOutputFormat.setOutputPath(jp, Path("user/gates/tmp/"));
        jp.setNumReduceTasks(1);
        Job loadPages = new Job(jp);

        JobConf lfu = new JobConf(MRExample.class);
        lfu.setJobName("Load and Filter");
        lfu.setInputFormat(TextInputFormat.class);
        lfu.setOutputKeyClass(Text.class);
        lfu.setOutputValueClass(Text.class);
        FileInputFormat.addInputPath(lfu, Path("user/gates/users"));
        FileOutputFormat.setOutputPath(lfu, Path("user/gates/tmp/"));
        lfu.setNumReduceTasks(1);
        Job loadUsers = new Job(lfu);

        JobConf join = new JobConf(MRExample.class);
        join.setJobName("Join Users and Pages");
        join.setInputFormat(KeyValueTextInputFormat.class);
        join.setOutputKeyClass(Text.class);
        join.setOutputValueClass(Text.class);
        join.setMapperClass(IdentityMapper.class);
        join.setReducerClass(Join.class);
        FileInputFormat.addInputPath(join, Path("user/gates/tmp/indexd_pages"));
        FileOutputFormat.setOutputPath(join, Path("user/gates/joined"));
        join.setNumReduceTasks(50);
        Job joinJob = new Job(join);
        joinJob.addDependingJob(loadPages);
        joinJob.addDependingJob(loadUsers);

        JobConf group = new JobConf(MRExample.class);
        group.setJobName("Group URLs");
        group.setInputFormat(KeyValueTextInputFormat.class);
        group.setOutputKeyClass(Text.class);
        group.setOutputValueClass(LongWritable.class);
        group.setOutputFormat(SequenceFileOutputFormat.class);
        group.setMapperClass(LoadAndFilterUsers.class);
        group.setReducerClass(ReduceUrls.class);
        FileInputFormat.addInputPath(group, Path("user/gates/tmp/joined"));
        FileOutputFormat.setOutputPath(group, Path("user/gates/tmp/grouped"));
        group.setNumReduceTasks(50);
        Job groupJob = new Job(group);
        groupJob.addDependingJob(joinJob);

        JobConf top100 = new JobConf(MRExample.class);
        top100.setJobName("Top 100 sites");
        top100.setInputFormat(SequenceFileInputFormat.class);
        top100.setOutputKeyClass(LongWritable.class);
        top100.setOutputValueClass(Text.class);
        top100.setOutputFormat(SequenceFileOutputFormat.class);
        top100.setMapperClass(LoadClicks.class);
        top100.setCombinerClass(LimitClicks.class);
        top100.setReducerClass(LimitClicks.class);
        FileInputFormat.addInputPath(top100, Path("user/gates/tmp/grouped"));
        FileOutputFormat.setOutputPath(top100, Path("user/gates/top100sitesforusers1"));
        top100.setNumReduceTasks(1);
        Job limit = new Job(top100);
        limit.addDependingJob(groupJob);

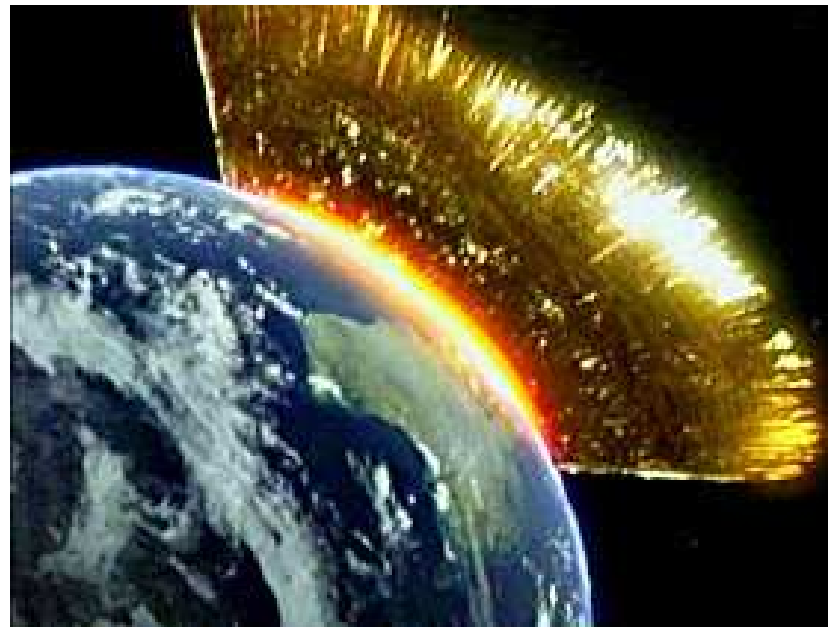
        JobControl jc = new JobControl();
        jc.addJob(loadPages);
        jc.addJob(loadUsers);
        jc.addJob(joinJob);
        jc.addJob(groupJob);
        jc.addJob(limit);
    }
}
```

**Users = LOAD 'users' AS (name, age);**  
**Fltrd = FILTER Users by age >= 18 and age <= 25;**  
**Pages = LOAD 'pages' AS (user, url);**  
**Jnd = JOIN Fltrd BY name, Pages BY user;**  
**Grpd = GROUP Jnd by url;**  
**Smm = FOREACH Grpd GENERATE group, COUNT(jnd) AS clicks;**  
**Srtd = ORDER Smm BY clicks;**  
**Top100 = LIMIT Srtd 100;**  
**STORE Top100 INTO 'top100sites';**



# Why (NOT) Pig?

- 不是史上究極霹靂大無敵武器
  - Focus: aggregation, filter, join,...
- 另一種做分散運算工作的方式

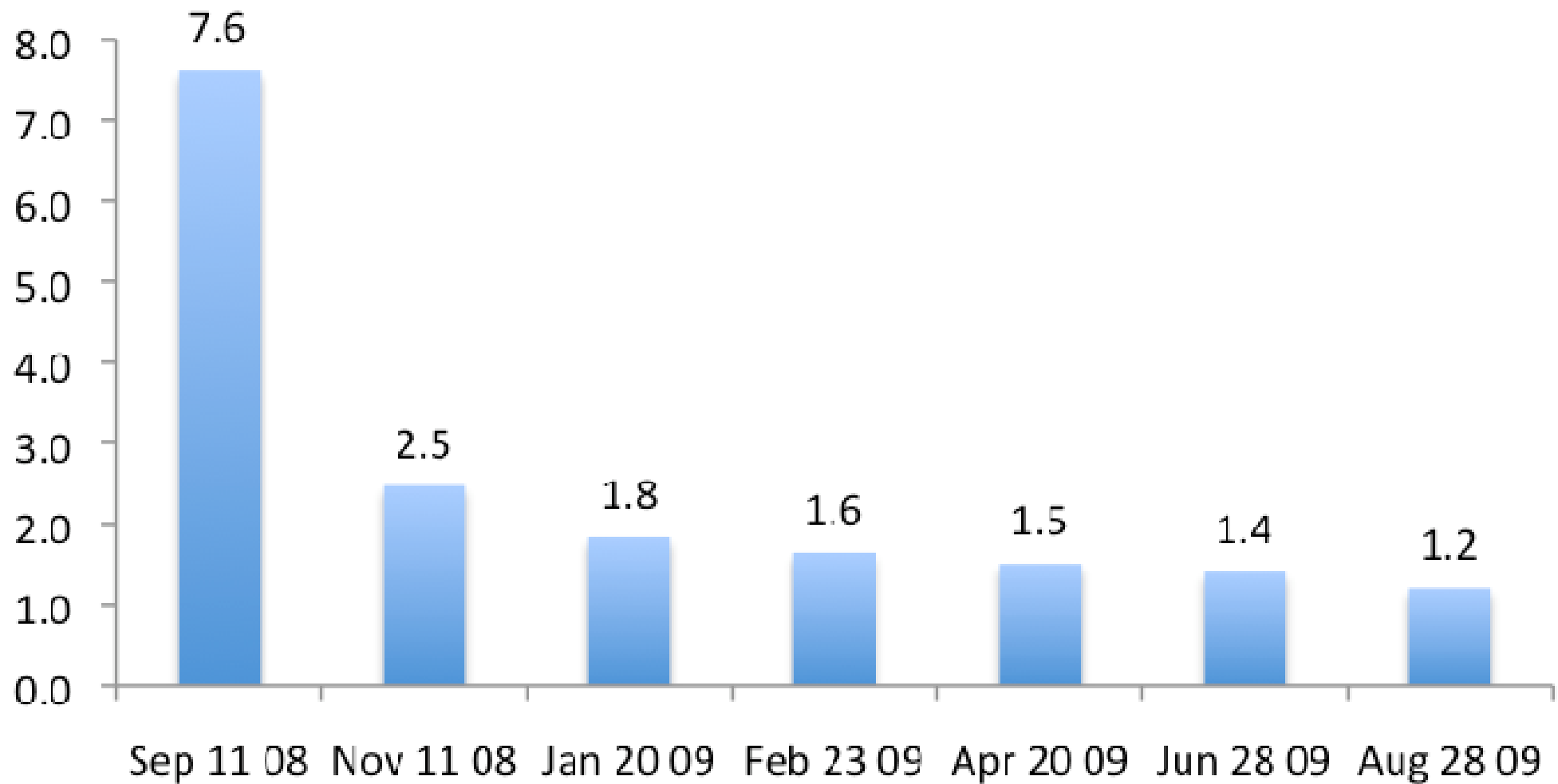


# Sweet spot between SQL – M/R

	SQL	Pig	Map-Reduce
<i>Programming style</i>	Large blocks of declarative constraints	→	“Plug together pipes”
<i>Built-in data manipulations</i>	Group-by, Sort, Join, Filter, Aggregate, Top-k, etc...	←	Group-by, Sort
<i>Execution model</i>	Fancy; trust the query optimizer	→	Simple, transparent
<i>Opportunities for automatic optimization</i>	Many	←	Few (logic buried in map() and reduce())
<i>Data Schema</i>	Must be known at table creation	→	Not required, may be defined at runtime



# Pig Performance vs Map-Reduce





# Execution and Syntax



# Pig Example

- Show users aged 18-25

```
Users = LOAD 'users.txt'  
        USING PigStorage(',') AS (name, age);  
Fltrd = FILTER Users  
        BY age >= 18 AND age <= 25;  
Names = FOREACH Fltrd GENERATE name;  
  
STORE Names INTO 'names.out';
```



# How to execute

- Local:

- `pig -x local foo.pig`

- Hadoop (HDFS):

- `pig foo.pig`

- `pig -Dmapred.job.queue.name=xxx foo.pig`

- `hadoop queue -showacIs`



# How to execute

- Interactive pig shell
  - `$ pig`
  - `grunt> _`

# Load Data

```
Users = LOAD 'users.txt'  
        USING PigStorage(',') AS (name, age);
```

- LOAD ... AS ...
- PigStorage(',') to specify separator

```
John,18  
Mary,20  
Bob,30
```



name	age
John	18
Mary	20
Bob	30

# Filter

```
Fltrd = FILTER Users  
      BY age >= 18 AND age <= 25;
```

- **FILTER ... BY ...**
  - constraints can be composite

name	age
John	18
Mary	20
Bob	30



name	age
John	18
Mary	20

# Generate / Project

```
Names = FOREACH Fltrd GENERATE name;
```

- FOREACH ... GENERATE

name	age
John	18
Mary	20



name
John
Mary

# Store Data

```
STORE Names INTO 'names.out';
```

- **STORE ... INTO ...**
  - PigStorage(',') to specify separator if multiple fields

# Command - JOIN

```
Users = LOAD 'users' AS (name, age);  
Pages = LOAD 'pages' AS (user, url);  
Jnd   = JOIN Users BY name, Pages BY user;
```

name	age
John	18
Mary	20
Bob	30

user	url
John	yaho
Mary	goog
Bob	bing



name	age	user	url
John	18	John	yaho
Mary	20	Mary	goog
Bob	30	Bob	bing



# Command - GROUP

```
Grpd = GROUP Jnd by url;  
describe Grpd;
```

name	age	url
John	18	yhoo
Mary	20	goog
Dee	25	yhoo
Kim	40	bing
Bob	30	bing



yhoo	(John, 18, yhoo) (Dee, 25, yhoo)
goog	(Mary, 20, goog)
bing	(Kim, 40, bing) (Bob, 30, bing)

# Other Commands

- `PARALLEL` – controls `#reducer`
- `ORDER` – sort by a field
- `COUNT` – eval: count `#elements`
- `COGROUP` – structured JOIN
- More at  
[http://hadoop.apache.org/pig/docs/r0.5.0/piglatin\\_reference.html](http://hadoop.apache.org/pig/docs/r0.5.0/piglatin_reference.html)





# Features

# Parameter Substitution

```
%default TYPE 'view'
```

```
%declare ID '18987'
```

```
A = load '/data/$DATE/$ID/$TYPE'
```

- `$ pig a.pig`
- `$ pig -param DATE=20091009 a.pig`
- `$ pig -param DATE=20091009 -param  
TYPE=click a.pig`



# RegEx Comparison

- `itsyou = FILTER` urls by  
(`$0 MATCHES 'http://.*\\.yahoo\\.com.*'`)
- **MATCHES matches 'whole' string**
  - `'aaaa' MATCHES 'aaa.*'` is true
  - `'bbaaaa' MATCHES 'aaa.*'` is false
- **pattern syntax:** `java.util.regex.Pattern`



# User-defined Function (UDF)

(John,171)  
(Mary,165)  
(Bob,183)



(**JOHN**,171)  
(**MARY**,165)  
(**BOB**,183)

# UDF – user function part

```
package myudf;
import java.io.IOException;
import org.apache.pig.EvalFunc;
import org.apache.pig.data.Tuple;

public class UPPER extends EvalFunc<String>
{
    public String exec(Tuple in) throws IOException {
        if (in == null || in.size() == 0) return null;
        String str = (String)in.get(0);
        return str.toUpperCase();
    }
}
```



# UDF

- <http://hadoop.apache.org/pig/docs/r0.3.0/udf.html>
- <http://hadoop.apache.org/pig/javadoc/docs/api/>
- **PiggyBank**
  - Pig users UDF repo
  - <http://wiki.apache.org/pig/PiggyBank>





# Embedded in Java

```
/* create a pig server in the main class*/
{
    PigServer pigserver = new PigServer(args[0]);
    runMyQuery(pigServer, "/user/viraj/mydata.txt")
}

/* submit in function runMyQuery */

runMyQuery(PigServer pigServer, String inputFile) throws
IOException {
    pigServer.registerQuery("A = load '" + inputFile +
    "' as (f1,f2,f3);");
    pigServer.registerQuery("B = group A by f1;");
    pigServer.registerQuery("C = foreach B generate
    flatten(group);");
    pigServer.store("C", "/user/viraj/myoutput");
}
```



# References

- **FAQ**
  - <http://wiki.apache.org/pig/FAQ>
- **Documentation**
  - <http://hadoop.apache.org/pig/docs/r0.5.0/>
- **Talks & papers**
  - <http://wiki.apache.org/pig/PigTalksPapers>
  - <http://www.cloudera.com/hadoop-training-pig-introduction>



Questions?





Backup slides

# Parameter Substitution

```
$ pig -param myparam=val foo.pig
```

```
B = filter A by ($0 eq '$myparam')
```

- `pig -dryrun` produces processed script

```
B = filter A by ($0 eq 'val')
```



# Parameter Substitution

- Params in file instead of command line
- `$ pig -param_file myparams.txt a.pig`

```
#myparams.txt  
DATE=20081009  
TYPE=clicks
```



# UDF – build user function

- `javac`
  - `-cp $PIG_HOME/lib/pig.jar`
  - `-sourcepath src`
  - `-d classes`
  - `src/myudf/UPPER.java`
- `jar cf myudf.jar -C classes`  
`myudf/UPPER.class`



# UDF – pig latin part

- **register** myudf.jar;
- B =  
foreach A generate  
    **myudf.UPPER(name)**, height;



# SQL vs. Pig Latin

<u>SQL</u>	<u>Pig</u>	<u>Example</u>
<b>From table</b>	<b>Load file(s)</b>	<b>SQL:</b> from X; <b>Pig:</b> A = load 'mydata' using PigStorage('\t') as (col1, col2, col3);
<b>Select</b>	<b>Foreach ... generate</b>	<b>SQL:</b> select col1 + col2, col3 ... <b>Pig:</b> B = foreach A generate col1 + col2, col3;
<b>Where</b>	<b>Filter</b>	<b>SQL:</b> select col1 + col2, col3 from X where col2>2; <b>Pig:</b> C = filter B by col2 > '2';

(adapted from Viraj's slide)



# SQL vs. Pig Latin

<u>SQL</u>	<u>Pig</u>	<u>Example</u>
<b>Group by</b>	<b>Group + foreach ... generate</b>	<b>SQL:</b> select col1, col2, sum(col3) from X group by col1, col2; <b>Pig:</b> D = group A by (col1, col2); E = foreach D generate flatten(group), SUM(A.col3);
<b>Having</b>	<b>Filter</b>	<b>SQL:</b> select col1, sum(col2) from X group by col1 having sum(col2) > 5; <b>Pig:</b> F = filter E by \$1 > '5';
<b>Order By</b>	<b>Order ... By</b>	<b>SQL:</b> select col1, sum(col2) from X group by col1 order by col1; <b>Pig:</b> H = ORDER E by \$0;

(adapted from Viraj's slide)



# SQL vs. Pig Latin

<u>SQL</u>	<u>Pig</u>	<u>Example</u>
<b>Distinct</b>	<b>Distinct</b>	<b>SQL:</b> select distinct col1 from X; <b>Pig:</b> I = foreach A generate col1; J = distinct I;
<b>Distinct Agg</b>	<b>Distinct in foreach</b>	<b>SQL:</b> select col1, count (distinct col2) from X group by col1; <b>Pig:</b> K = foreach D { L = distinct A.col2; generate flatten(group), SUM(L); }

(adapted from Viraj's slide)



# SQL vs. Pig Latin

<u>SQL</u>	<u>Pig</u>	<u>Example</u>
<b>Join</b>	<b>Cogroup + flatten</b>  <b>(also shortcut: JOIN)</b>	<b>SQL:</b> select A.col1, B.col3 from A join B using (col1);  <b>Pig:</b> A = load 'data1' using PigStorage('\t') as (col1, col2); B = load 'data2' using PigStorage('\t') as (col1, col3); C = cogroup A by col1 <b>inner</b> , B by col1 <b>inner</b> ; D = foreach C generate flatten(A), flatten(B); E = foreach D generate A.col1, B.col3;

(adapted from Viraj's slide)



# Debug Tips

- Use small data and `pig -x local`
- LIMIT
  - `A = LOAD 'data' AS (a1,a2,a3)`
  - `B = LIMIT A 3;`
- `DUMP` , `DESCRIBE`

# FAQ

- <http://wiki.apache.org/pig/FAQ>
  - can assign #reducer
  - support regex
  - can use allocated HOD cluster

# pig.vim

- [http://www.vim.org/scripts/script.php?script\\_id=2186](http://www.vim.org/scripts/script.php?script_id=2186)

```
A = load 'data.txt' as (f1,f2,f3);  
dump A;  
B = foreach A generate f1,f3;  
dump B;  
store B into 'output.txt' using PigStorage('-');
```