

Course Information 課程資訊

- 講師介紹 About Me :

- 國網中心 王耀聰 副研究員 / 交大電控碩士
- Yao-Tsung Wang (Jazz) / Associate Researcher, NCHC
- Master, Electrical and Control Engineering, NCTU, Taiwan
- jazz@nchc.org.tw



- 由於雲端資訊變動太快，愛護地球，請減少不必要之講義列印。

It changes too fast, don't waste your paper !!

- 更多資訊 All Info. will be updated :

- <http://trac.nchc.org.tw/cloud>
- <http://www.classcloud.org/media> - training course video archives
- <http://www.screentoaster.com/user?username=jazzwang>

- 若需要實驗環境 If you need an environment of Hadoop :

- <http://hadoop.nchc.org.tw>

- 相關問題討論 If you have questions about Hadoop :

- <http://forum.hadoop.tw>



運用自由軟體打造私有雲端

Build Your Own Private Cloud using Open Source

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



Powered by DRBL

Let's have a

QUICK

REVIEWS

about Cloud



什麼是雲端運算啊？可以個簡單的定義嗎？

What is Cloud Computing ?

雲端運算怎麼聽起來要買一些新硬體、新軟體啊？

Is it about buying NEW Hardware and Software?



雲端運算可能只是拿來振興經濟的幌子吧？

Is it a trap to another bubble economy ?

我聽你們在那裡講五四三.....

Cloud Computing is as simple as 5..4..3..2..1...



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

On-demand self-service.

隨需自助服務

Broad network access

隨時隨地用任何網路裝置存取

Resource pooling

多人共享資源池

Rapid elasticity

快速重新佈署靈活度

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

IaaS

Infrastructure as a Service

架構即服務

PaaS

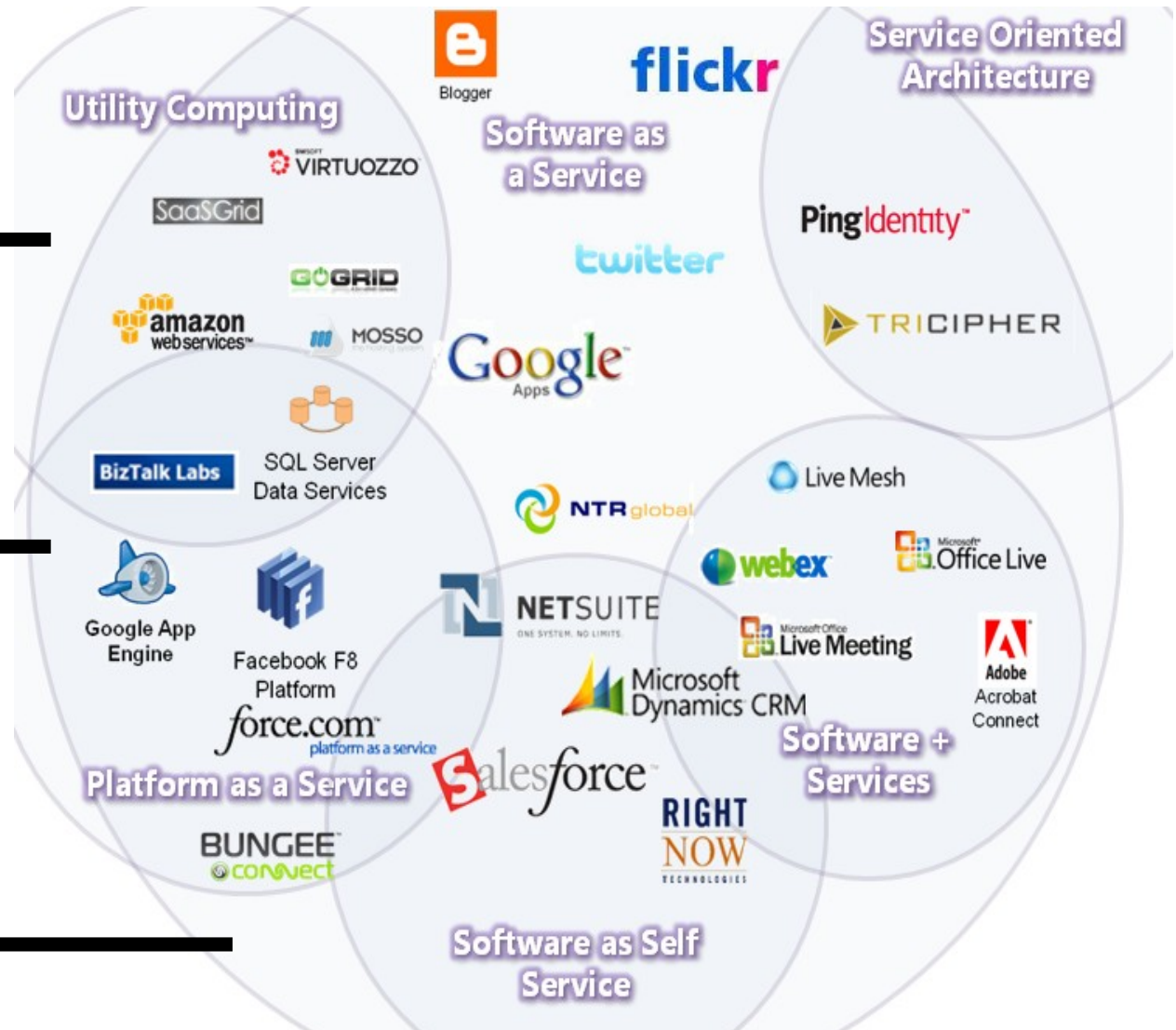
Platform as a Service

平台即服務

SaaS

Software as a Service

軟體即服務



2 R&D directions : Cloud or Device

兩大研究方向：你該選「雲」還是「端」？



One key spirit of Cloud Computing

用一句話說明雲端運算！服務才是王道！

Anytime 隨時

Anywhere 隨地

With Any Devices 使用任何裝置

Accessing Services 存取各種服務

Cloud Computing =~ ***Network Computing***

雲端運算 =~ 網路運算

Key spirit of Cloud ~

形成服務才是重點！！

Everything as a Service !!

Everything as a Service 啥米鬼都是一種服務

- AaaS Architecture as a Service
- BaaS Business as a Service
- CaaS Computing as a Service
- DaaS Data as a Service
- DBaaS Database as a Service
- EaaS Ethernet as a Service
- FaaS Frameworks as a Service
- GaaS Globalization or Governance as a Service
- HaaS Hardware as a Service
- IMaaS Information as a Service

• **IaaS Infrastructure or Integration as a Service**

- IDaaS Identity as a Service
- LaaS Lending as a Service
- MaaS Mashups as a Service
- OaaS Organization or Operations as a Service

• **SaaS Software or Storage as a Service**

• **PaaS Platform as a Service**

- TaaS Technology or Testing as a Service
- VaaS Voice as a Service

Customer-Oriented

客戶導向，服務至上

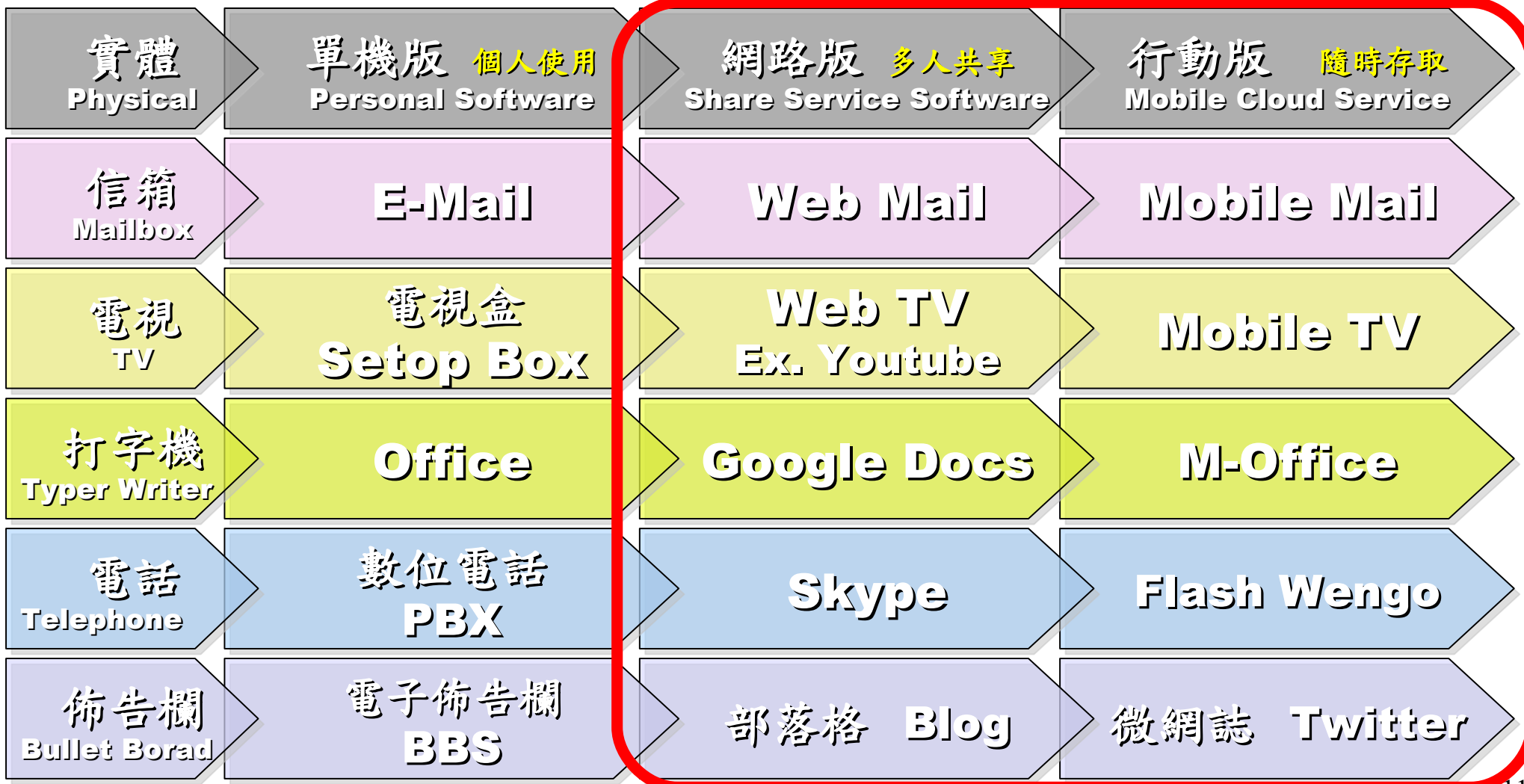
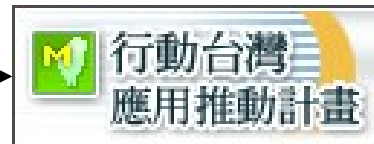
能把 AAA 做好就很強了

Authentication
Authorization
Accounting
as
a
Service

Evolution of Cloud Services

雲端服務只是軟體演化史的必然趨勢

數位化



Rome wasn't built in a day !

羅馬不是一天造成的！



圖片來源：<http://www.mjfq.com/pic/20070822/20070822234234402.jpg>

When did the Cloud come ?!

這朵雲幾時飄過來的？！

Brief History of Computing (1/5)



Source: <http://pinedakrch.files.wordpress.com/2007/07/>

**Mainframe
Super
Computer**

1960 PDP-1

*·
·
·*

1965 PDP-7

*·
·
·*

1969 1st Unix

1977 Apple II

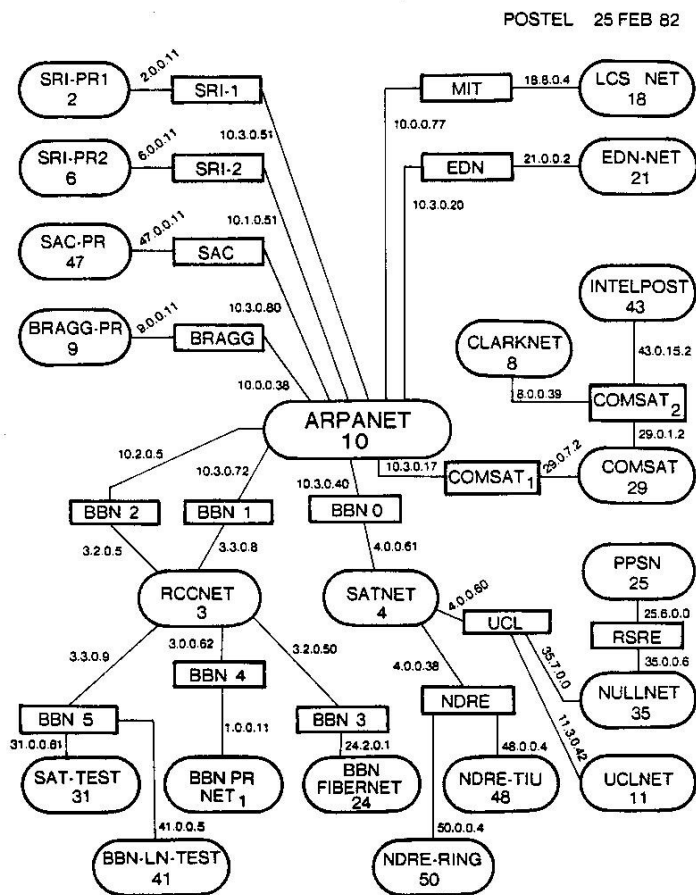


1981 IBM 1st PC 5150

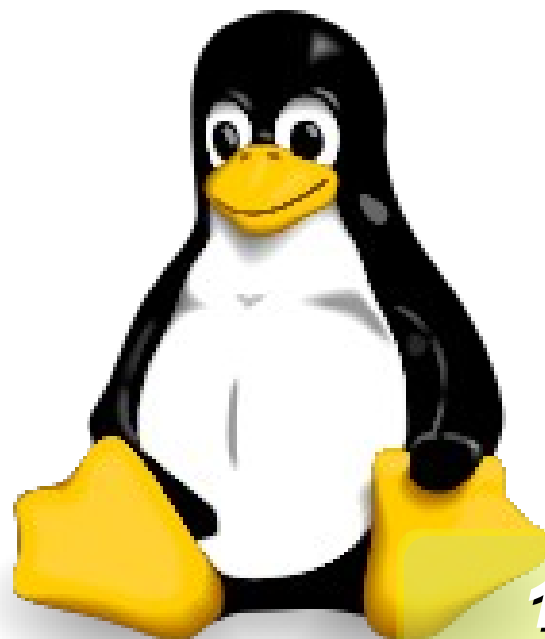


Back to Year 1970s ...

1982 TCPIIP



1983 GNU



1991 Linux

Back to Year 1980s ...

Brief History of Computing (2/5)



Source: <http://www.nchc.org.tw>

Mainframe
Super
Computer

PC | Linux
Cluster
Parallel

**1990 World Wide Web
by CERN**

...

...

**1993 Web Browser
Mosaic by NCSA**



1991 CORBA

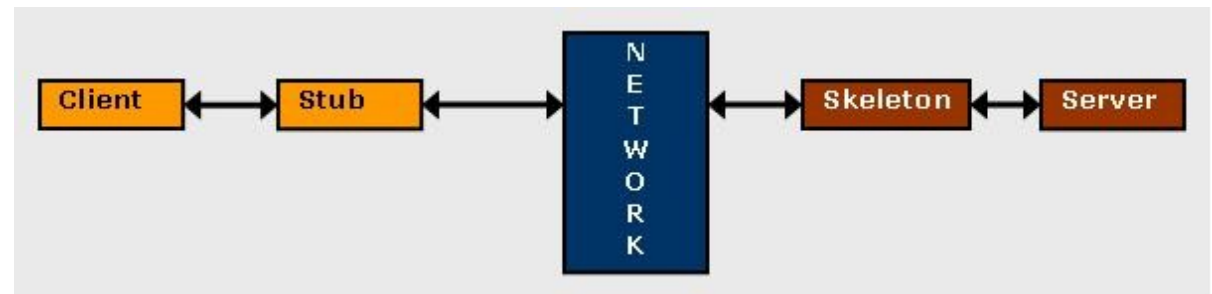
...

Java RMI

Microsoft DCOM

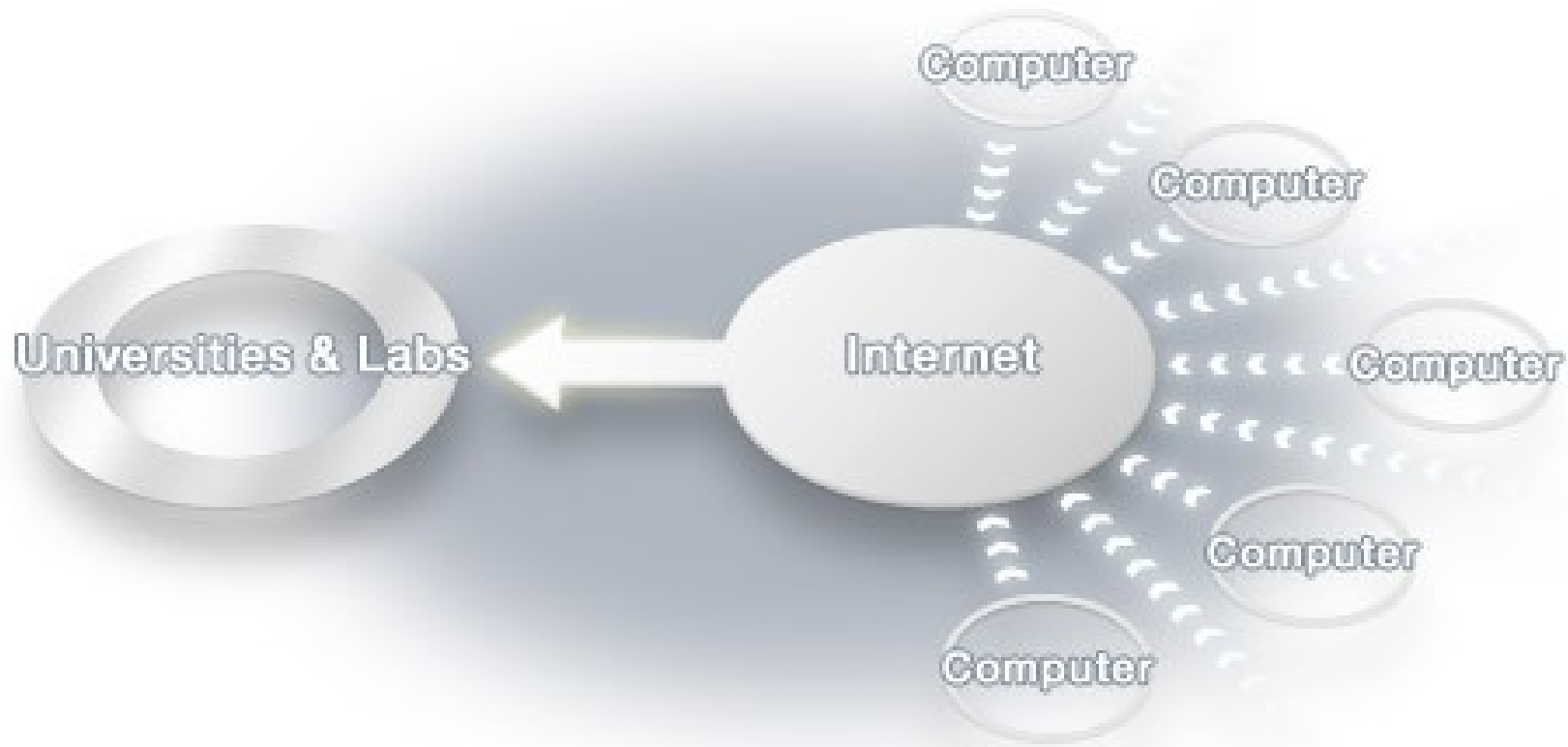
...

Distributed Objects



Back to Year 1990s ...

Brief History of Computing (3/5)



Source: <http://www.scei.co.jp/folding/en/dc.html>

Mainframe
*Super
Computer*

PC | Linux
*Cluster
Parallel*

Internet
*Distributed
Computing*

1997 Volunteer Computing
1999 SETI@HOME



2003 Globus Toolkit 2



2002 Berkley BOINC



2004 EGEE gLite



Back to Year 2000s ...

Brief History of Computing (4/5)



Source: <http://gridcafe.web.cern.ch/gridcafe/whatisgrid/whatis.html>

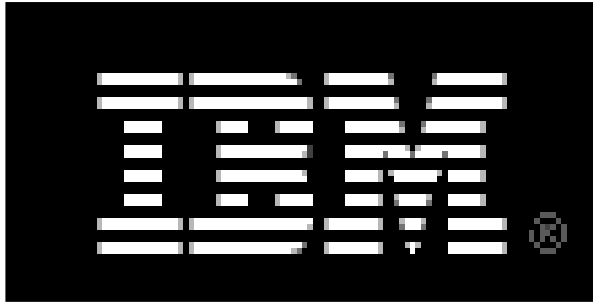
Mainframe
*Super
Computer*

PC | Linux
*Cluster
Parallel*

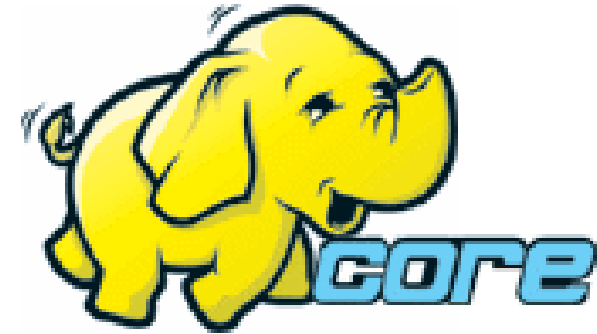
Internet
*Distributed
Computing*

Virtual Org.
*Grid
Computing*

2001 Autonomic Computing
IBM



2006 Apache Hadoop



2005 Utility Computing
Amazon EC2 | S3

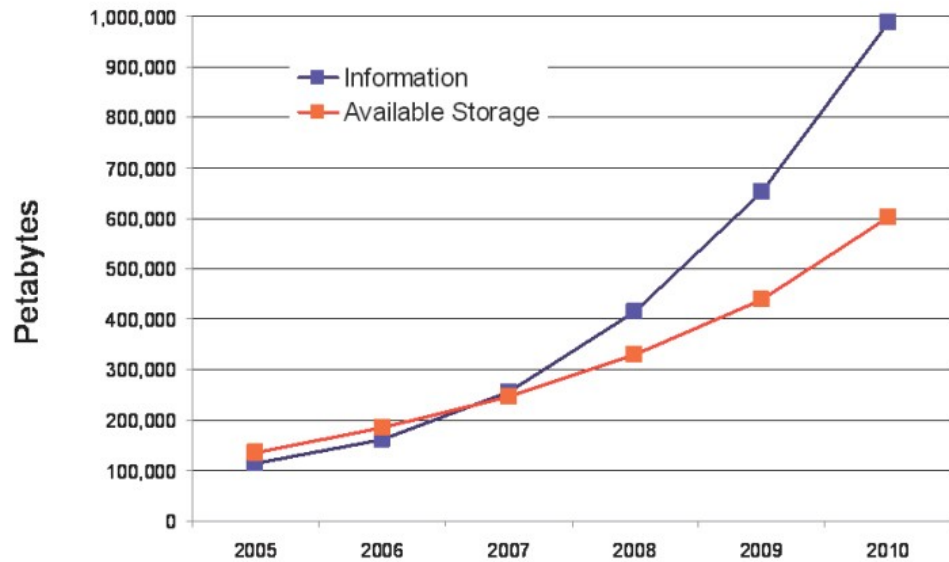


2007 Cloud Computing
Google + IBM



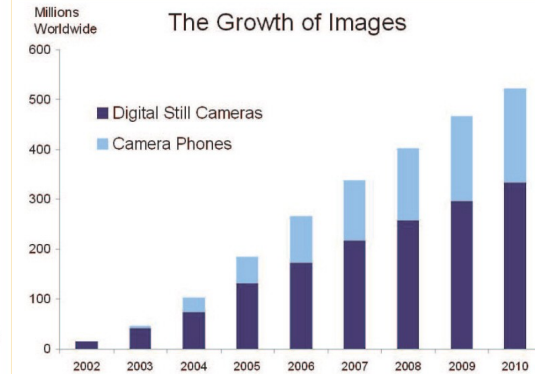
Back to Year 2007 ...

Information Versus Available Storage



2007 Data Explore

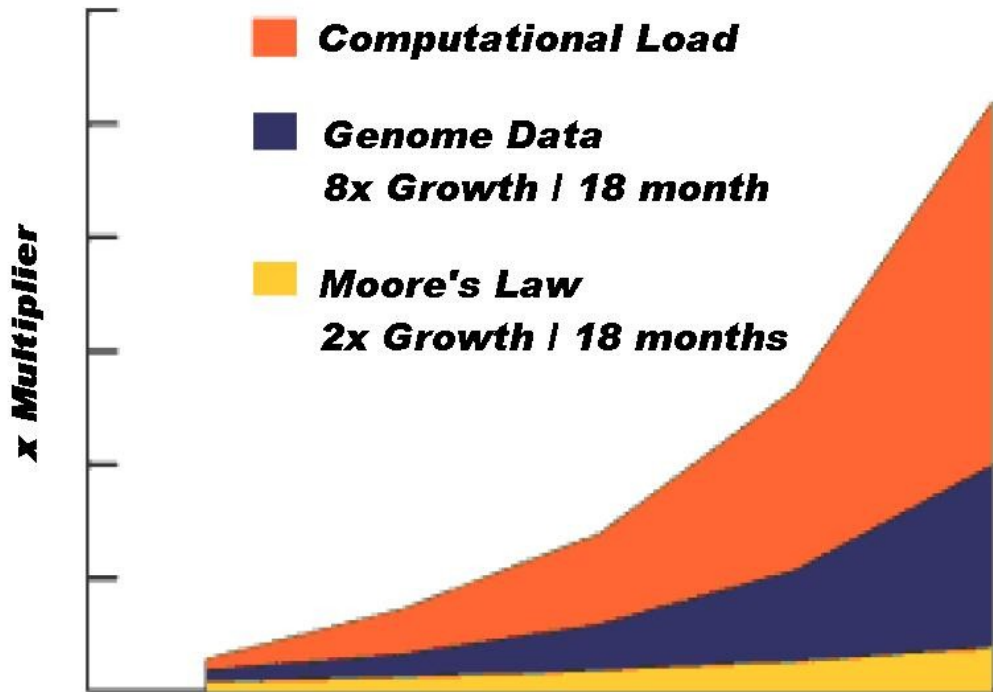
Top 1 : Human Genomics – 7000 PB / Year
Top 2 : Digital Photos – 1000 PB+/ Year
Top 3 : E-mail (no Spam) – 300 PB+ / Year



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

Source: IDC, 2007

Source: IDC, 2007

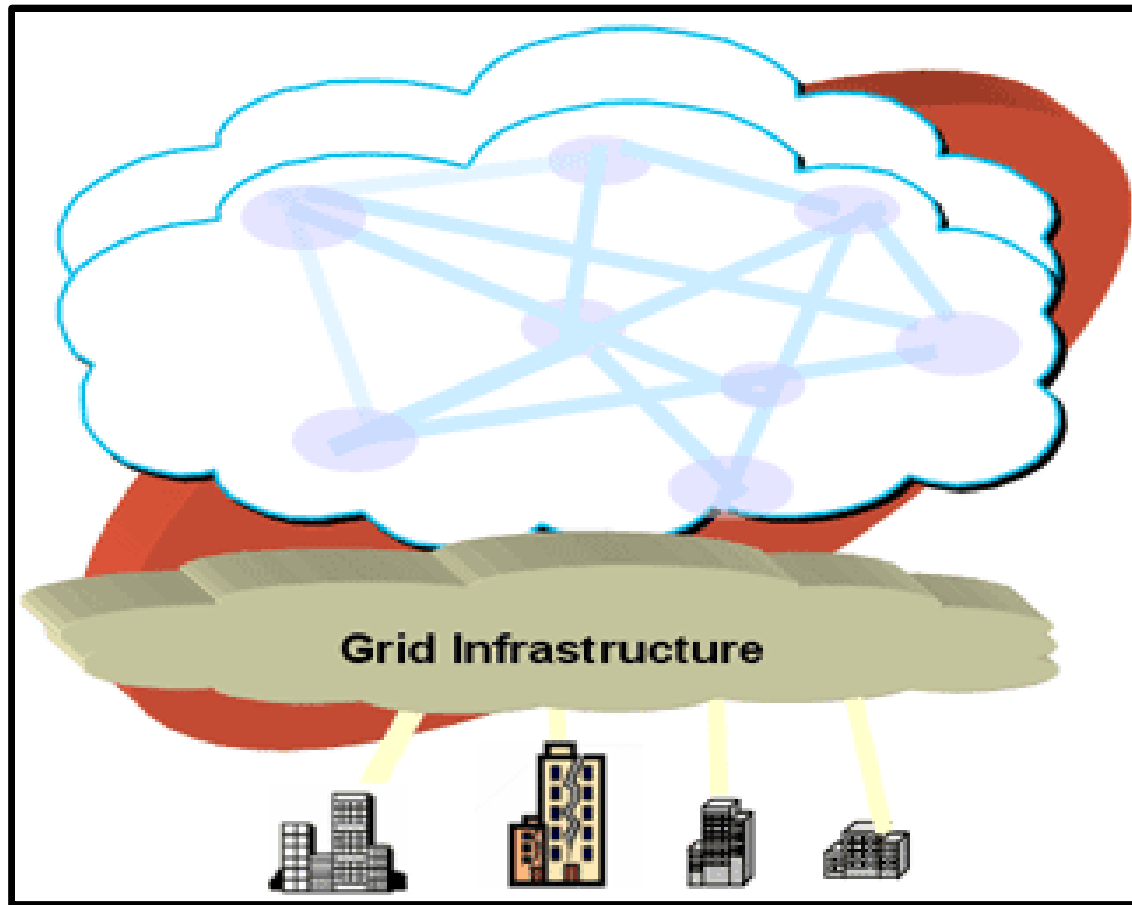


Particle Physics Large Hadron Collider (15PB)	Human Genomics (7000PB) 1GB / person 200PB+ captured 200% CAGR	World Wide Web (~1PB)	Wikipedia (10GB) 100% CAGR
Annual Email Traffic, no spam (300PB+)	Internet Archive (1PB+)	Estimated On-line RAM in Google (8PB)	Personal Digital Photos (1000PB+) 100% CAGR
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 Babytalk 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 270,000PB (IDC)			

Phillip B. Gibbons, Data-Intensive Computing Symposium

Source: http://lib.stanford.edu/files/see_pasig_dic.pdf

Brief History of Computing (5/5)



Source: <http://mmdays.com/2008/02/14/cloud-computing/>

mainframe
super
computer

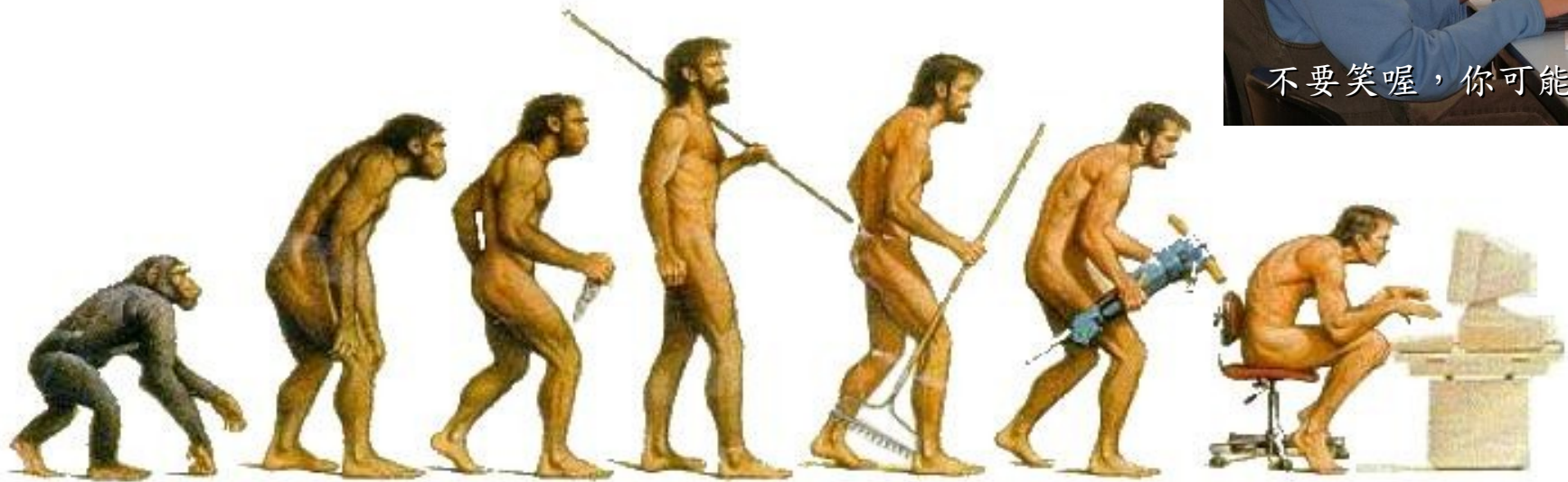
PC / Linux
Cluster
Parallel

Internet
Distributed
Computing

Virtual Org.
Grid
Computing

Data Explode
Cloud
Computing

Evolution



(OR is it?)

What can we learn from the past ?!

在這漫長的演化中，我們到底學到些什麼?!

Source: <http://cyberpingui.free.fr/humour/evolution-white.jpg>

Lesson #1: One cluster can't fit all !

教訓一：叢集的單一設定無法滿足所有需求！

Answer #1: Virtual Cluster 新服務：虛擬化叢集

Lesson #2: Grid for Heterogeneous Enterprise !

教訓二：格網運算該用在異業結盟的資源共享！

Answer #2: Peak Usage Time 尖峰用量發生時間點

Lesson #3: Extra cost to move data to Grid !

教訓三：資料搬運的網路與時間成本！

Answer #3: Total Cost of Ownership 總擁有成本

This is why Cloud Computing matters ?!

這就是為什麼雲端運算變得熱門?!

What are the trend of next 10 years ?

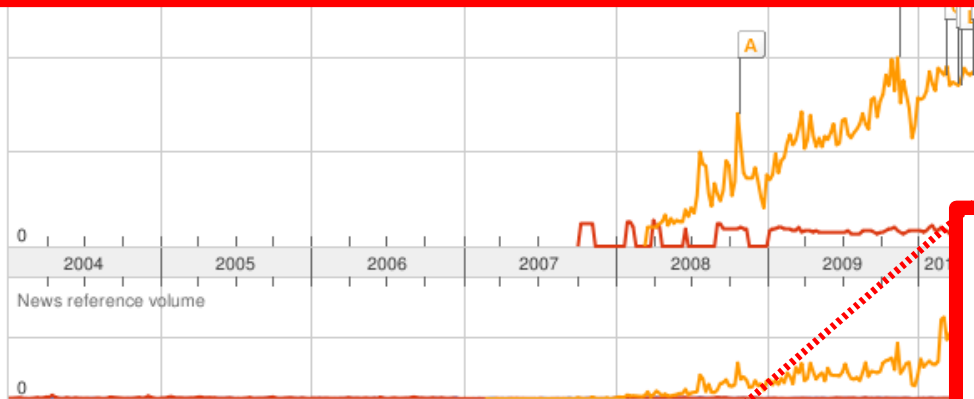
什麼是下個十年的熱門技能？

● distributed computin... ● grid computing ● cloud computing

[Sign in](#) to see and export additional Tren

Search Volume index

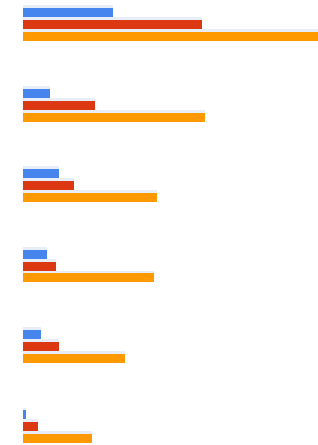
All regions All years



- ["cloud" computing space](#)
Canada.com - Oct 20 2008
- [Microsoft's cloud computing system is growing up](#)
Philadelphia Inquirer - Nov 17 2009
- [Google looks to be 'cloud-computing' rainmaker for other online business services](#)
Winnipeg Free Press - Mar 10 2010

Regions

- [India](#)
- [Singapore](#)
- [South Korea](#)
- [Hong Kong](#)
- [Taiwan](#)
- [Ireland](#)



Regions

- [India](#)
- [Singapore](#)
- [South Korea](#)
- [Hong Kong](#)
- [Taiwan](#)
- [Ireland](#)

Cities

- Bangalore, India
- Mahape, India
- Mumbai, India
- Chennai, India
- San Jose, CA, USA
- Delhi, India

似乎亞洲國家特別熱愛雲端?! **Too Hot in Asia ?!**

CIO 2010 : Virtualization, Cloud and Web 2.0

CIO strategic technologies reflect increased interest in “lighter-weight” solutions

CIO technologies

Ranking of technologies CIOs selected as one of their top 5 priorities in 2010

Ranking	2010		2009	2008	2007
Virtualization	1	↑	3	3	5
Cloud computing	2	↑	16	*	*
Web 2.0	3	↑	15	15	*
Networking, voice and data communications	4	↑	6	7	4
Business intelligence (BI)	5	↓	1	1	1
Mobile technologies	6	↑	12	12	11
Data/document management and storage	7	↑	10	9	9
Service-oriented applications and architecture	8	↑	9	10	7
Security technologies	9	↓	8	5	6
IT management	10		*	*	*
Enterprise applications	11	↓	2	2	2

* New question for that year

Source: *Gartner Executive Programs : “ Leading in Times of Transition: The 2010 CIO Agenda ”*

Trend #1: Data are moving to the Cloud

趨勢一：資料開始回歸集中管理

Access data anywhere anytime 為了隨時存取

Reduce the risk of data lost 降低資料遺失風險

Reduce data transfer cost 減少資料傳輸成本

Enhance team collaboration 促進團隊協同合作

How to store huge data ?!

如何儲存大量資料呢?!

Trend #2: Web become default Platform!

趨勢二：網頁變成預設開發平台

Open Standard 網頁是開放標準

Open Implementation 實作不受壟斷

Cross Platform 瀏覽器成為跨平台載具

Web Application 網頁程式設計成為顯學

Browser difference become entry barrier ?!

瀏覽器的差異造成新的技術門檻 ?!

Trend #3: HPC become a new industry

趨勢三：高速計算已悄悄變成新興產業

Parallel Computing 平行運算的技能

Distributed Computing 分散運算的技能

Multi-Core Programming 多核心程式設計

Processing Big Data 處理大資料的技能

Education and Training are needed !!

為了讓這些技能與產業接軌，亟需教育訓練！！



***Flying to the Cloud ...
or
Falling to the Ground ...***

Source: http://media.photobucket.com/image/falling%20ground/preeto_f10/falling

該使用別人打造的雲端，還是自己打造專屬雲端呢？

Let's SKIP Public Cloud

公用雲端服務，講過了就跳過啦！！

Public Cloud

公用雲端



Microsoft

Google

Target Market

is **S.M.B.**

主要客戶為

中小企業

*Hybrid
Cloud*

以**大型企業**
為主要客戶
Enterprise is
key market

Community Cloud

社群雲端

IBM®

私有雲端

Private Cloud

Academia 學術為主

How can we build our Private Cloud ??

那我們如何打造私有雲端呢??

Public Cloud

公用雲端



Target Market

is **S.M.B.**

主要客戶為

中小企業

**Hybrid
Cloud**

以**大型企業**
為主要客戶
**Enterprise is
key market**

Community Cloud

社群雲端



私有雲端

Private Cloud

Academia **學術**為主

Reference Cloud Architecture

雲端運算的參考架構

應用軟體 Application

Social Computing, Enterprise, ISV, ...

程式語言 Programming

Web 2.0 介面, Mashups, Workflows, ...

控制管理 Control

Qos Negotiation, Admission Control, Pricing, SLA Management, Metering...

虛擬化 Virtualization

VM, VM management and Deployment

硬體設施 Hardware

Infrastructure: Computer, Storage, Network

User-Level

User-Level
Middleware

Core
Middleware

System Level

IaaS
PaaS
SaaS

Open Source for Private Cloud

建構私有雲端運算架構的自由軟體

應用軟體 Application

Social Computing, Enterprise, ISV, ...

eyeOS, Nutch, ICAS,
X-RIME, ...

程式語言 Programming

Web 2.0 介面, Mashups, Workflows, ...

Hadoop (MapReduce),
Sector/Sphere, AppScale

控制管理 Control

Qos Negotiation, Admission Control,
Pricing, SLA Management, Metering...

OpenNebula, Enomaly,
Eucalyptus, OpenQRM, ...

虛擬化 Virtualization

VM, VM management and Deployment

Xen, KVM, VirtualBox,
QEMU, OpenVZ, ...

硬體設施 Hardware

Infrastructure: Computer, Storage, Network

Building IaaS with Open Source

用自由軟體打造 IaaS 服務

應用軟體 Application
Social Computing, Enterprise, ISV, ...

eyeOS, Nutch, ICAS,
X-RIME, ...

程式語言 Programming
Web 2.0 介面, Mashups, Workflows, ...

Hadoop (MapReduce),
Sector/Sphere, AppScale

控制管理 Control
Qos Negotiation, Admission Control,
Pricing, SLA Management, Metering...

OpenNebula, Enomaly,
Eucalyptus, OpenQRM, ...

虛擬化 Virtualization
VM, VM management and Deployment

Xen, KVM, VirtualBox,
QEMU, OpenVZ, ...

硬體設施 Hardware
Infrastructure: Computer, Storage, Network

Open Cloud #1: *Eucalyptus*

- 原是加州大學聖塔芭芭拉分校 (UCSB) 的研究專案
- **It was a research project of UCSB, USA**
- 目前已轉由 Eucalyptus System 這間公司負責維護
- **Now Eucalyptus System provide technical supports.**
- 創立目的是讓使用者可以**打造自己的 EC2**
- **It designed to help user to build their own Amazon EC2**
- 特色是相容於 Amazon EC2 既有的用戶端介面
- **Its feature is compatible with existing EC2 client.**
- 優勢是 Ubuntu 9.04 已經收錄 Eucalyptus 的套件
- **Ubuntu Enterprise Cloud powered by Eucalyptus in 9.04**
- 目前有提供 Eucalyptus 的官方測試平台供註冊帳號
- **You can register trail account at <http://open.eucalyptus.com/>**
- 缺點：目前仍有部分操作需透過指令模式
- **Cons : you might need to type commands in some case**



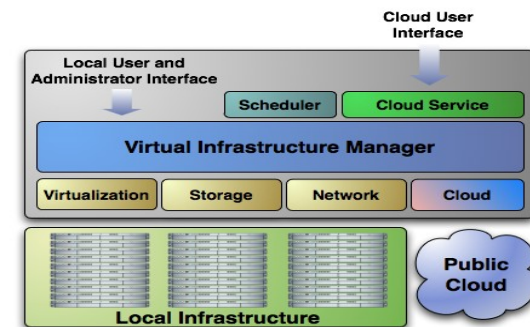
Eucalyptus

關於 Eucalyptus 的更多資訊，請參考
<http://trac.nchc.org.tw/grid/wiki/Eucalyptus>

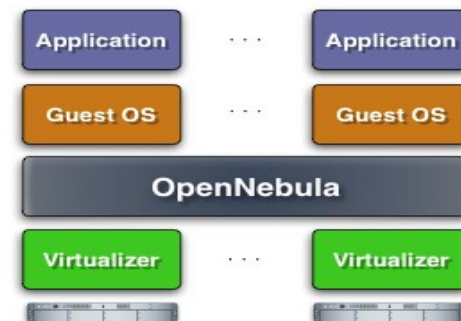
Open Cloud #2: *OpenNebula*

- <http://www.opennebula.org>
- 由歐洲研究學會 (European Union FP7) 贊助
- **Sponsor by European Union FP7**
- 將實體叢集轉換成具管理彈性的虛擬基礎設備
- Turn Physical Cluster into Virtual Cluster
- 可管理**虛擬叢集**的狀態、排程、遷徙 (migration)
- **manage status, scheduling and migration of virtual cluster**
- [Ubuntu 9.04 provide package of opennebula](#)
- 缺點：需下指令來進行虛擬機器的遷徙 (migration) 。
- **Cons** : You need to type commands to check or migration

OpenNebula.org



關於 OpenNebula 的更多資訊，請參考 <http://trac.nchc.org.tw/grid/wiki/OpenNEbula>



Building PaaS with Open Source

用自由軟體打造 PaaS 雲端服務

應用軟體 Application
Social Computing, Enterprise, ISV, ...

eyeOS, Nutch, ICAS,
X-RIME, ...

程式語言 Programming
Web 2.0 介面, Mashups, Workflows, ...

Hadoop (MapReduce),
Sector/Sphere, AppScale

控制管理 Control
Qos Negotiation, Admission Control,
Pricing, SLA Management, Metering...

OpenNebula, Enomaly,
Eucalyptus, OpenQRM, ...

虛擬化 Virtualization
VM, VM management and Deployment

Xen, KVM, VirtualBox,
QEMU, OpenVZ, ...


硬體設施 Hardware
Infrastructure: Computer, Storage, Network

Open Cloud #3: **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**

- <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MalStone效能評比軟體
- **Open Cloud Consortium provide Open Cloud Testbed and develop MalStone toolkit for benchmark**

What we learn today ?

WHAT

隨時隨地用任何裝置存取各種服務 !!

Accessing services with any device anytime anywhere!!

WHO

亞馬遜、谷歌、微軟等！ 什麼都可以是服務 ~

Amazon, Google, Microsoft and more! Everything as a Service!

WHEN

雲端運算是 2007 年繼格網運算之後的新趨勢 !!

Cloud Computing become new trend since year 2007 !!

WHY

資料集中、虛擬化、異業資源共享

Data-intensive, Virtualization, Heterogeneous

HOW

採用自由軟體也能打造私有雲端

Hadoop, Sectore/Sphere, Eucalyptus, and more



Questions?

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

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



Powered by **DRBL**

Attribution-Noncommercial-Share Alike 3.0 Taiwan



姓名標示-非商業性-相同方式分享 3.0 台灣

您可自由：



分享 — 重製、散布及傳輸本著作



重混 — 修改本著作

惟需遵照下列條件：



姓名標示 — 您必須按照著作人或授權人所指定的方式，表彰其姓名（但不得以任何方式暗示其為您或您使用本著作的方式背書）。



非商業性 — 您不得為商業目的而使用本著作。



相同方式分享 — 若您變更、變形或修改本著作，您僅得依本授權條款或與本授權條款類似者來散布該衍生作品。

<http://creativecommons.org/licenses/by-nc-sa/3.0/tw/>

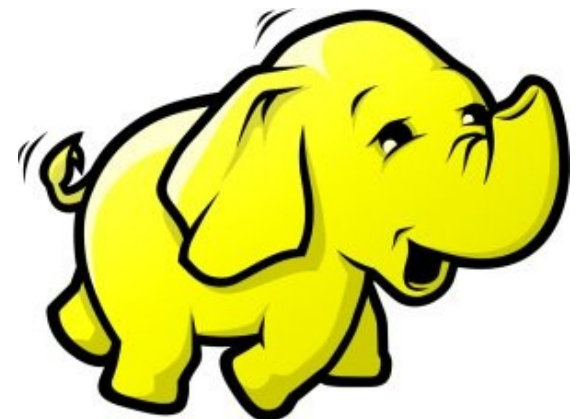
These slides could be distributed by Creative Commons License.



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

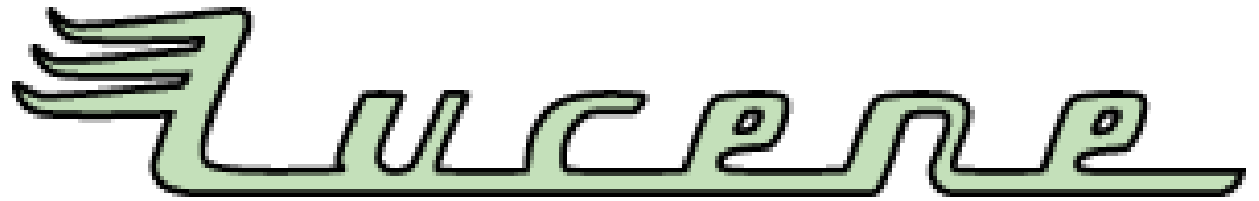


Doug Cutting Talks About The Founding Of Hadoop

<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 i n 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>



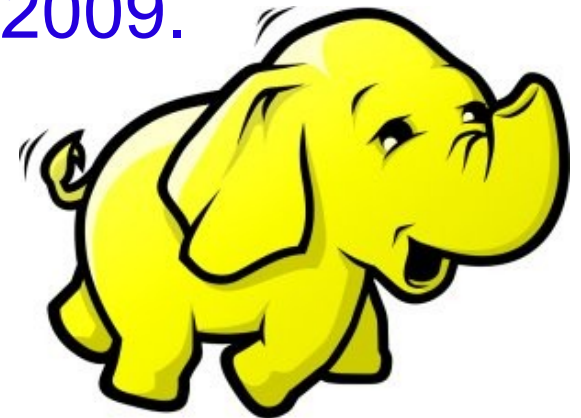
History of Hadoop ... 2004 ~ Now

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
- **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

Performance improvement of Hadoop

Hadoop 過去幾年的效能改進 (from Yahoo)

年份	日期	節點數	耗時 (小時)
2006	四月	188	47.9
2006	五月	500	42
2006	十一月	20	1.8
2006	十一月	100	3.3
2006	十一月	500	5.2
2006	十一月	900	7.8
2007	七月	20	1.2
2007	七月	100	1.3
2007	七月	500	2
2007	七月	900	2.5

Sort benchmark, every nodes with terabytes data.

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

Total Nodes	4000
Total cores	30000
Data	16PB

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

Comparison between Google and Hadoop

Google 與 Hadoop 的比較表

Develop Group	Google	Apache
Sponsor	Google	Yahoo, Amazon
Algorithm Method	MapReduce	MapReduce
Resource	open document	open source
File System (MapReduce)	GFS	HDFS
Storage System (for structure data)	big-table	HBase
Search Engine	Google	Nutch
OS	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[®]

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

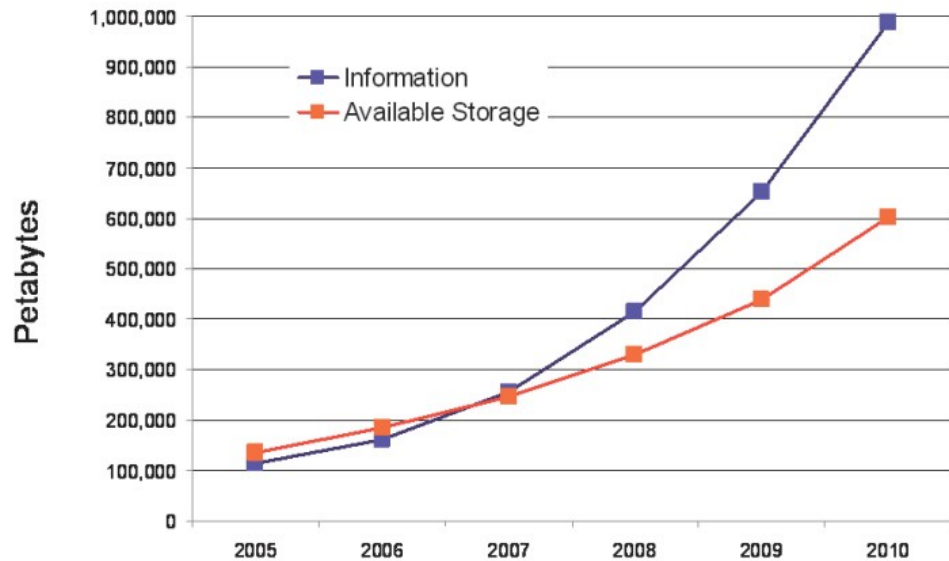
2. Data Mining Tool

方便作資料探勘的工作

3. Looking for Jobs

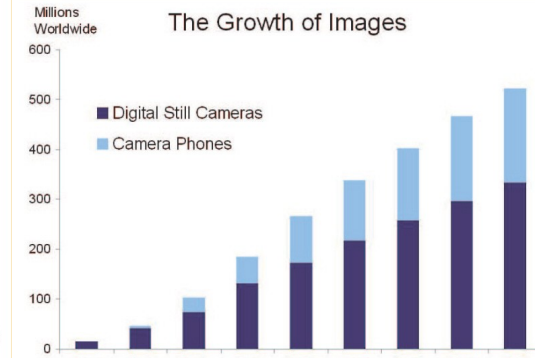
好找工作 !!

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



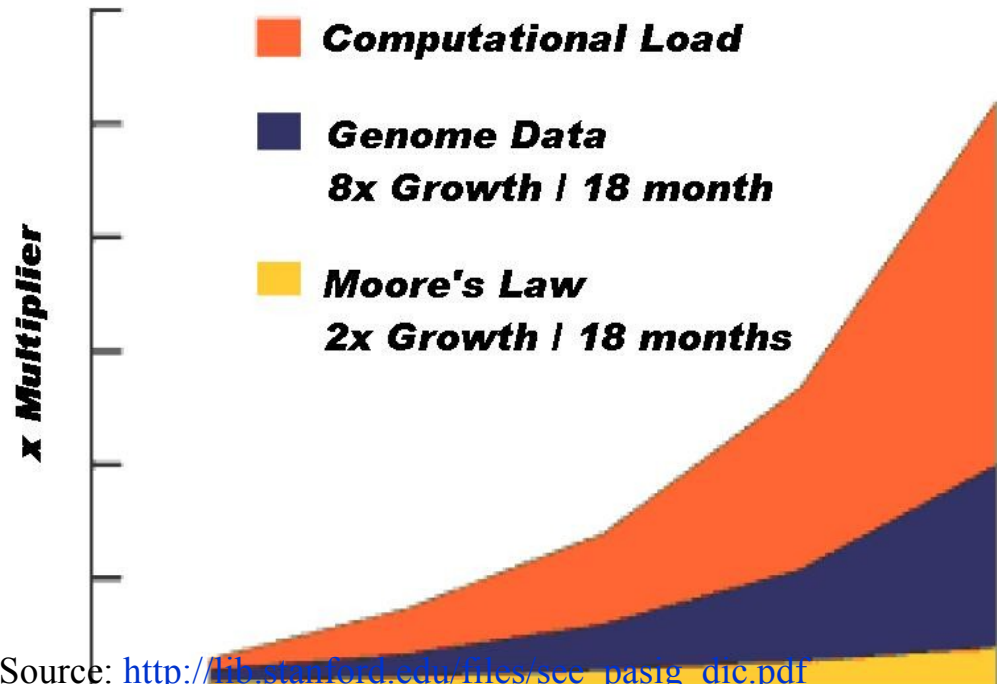
Source: <http://www.emc.com/collateral/analyst-reports/expanding-digital-idc-white-paper.pdf>

Source: IDC, 2007

Source: IDC, 2007

Source: IDC, 2007

- Computational Load**
- Genome Data**
8x Growth / 18 month
- Moore's Law**
2x Growth / 18 months



Source: http://lib.stanford.edu/files/sec_pasig_dtc.pdf

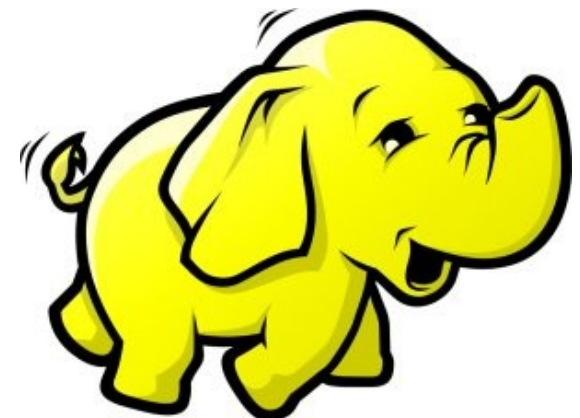
Particle Physics Large Hadron Collider (15PB)	Human Genomics (7000PB) 1GB / person 200PB+ captured 200% CAGR	World Wide Web (~1PB)	Wikipedia (10GB) 100% CAGR
Annual Email Traffic, no spam (300PB+)	Internet Archive (1PB+)	Estimated On-line RAM in Google (8PB)	Personal Digital Photos (1000PB+) 100% CAGR
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 Babytalk 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 270,000PB (IDC)			



Hadoop 專業術語

Introduction to Hadoop Terminology

Jazz Wang
Yao-Tsung Wang
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

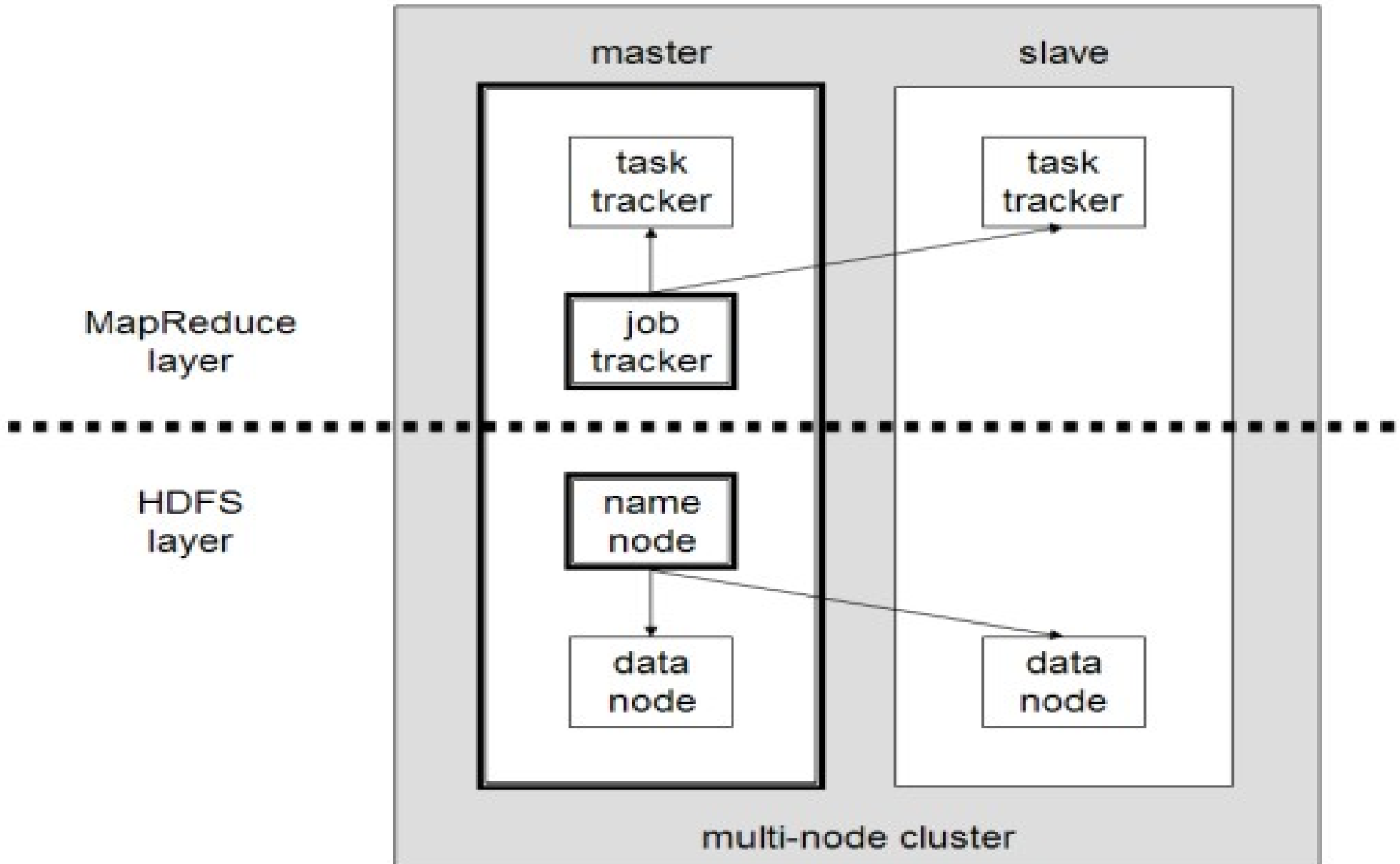
- **Master Node**
- **Receive Jobs from Hadoop Clients**
- **Assigned Tasks to TaskTrackers**
- **Define Job Queuing Policy, Priority and Error Handling**
- **Single Point of Failure**

TaskTracker

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

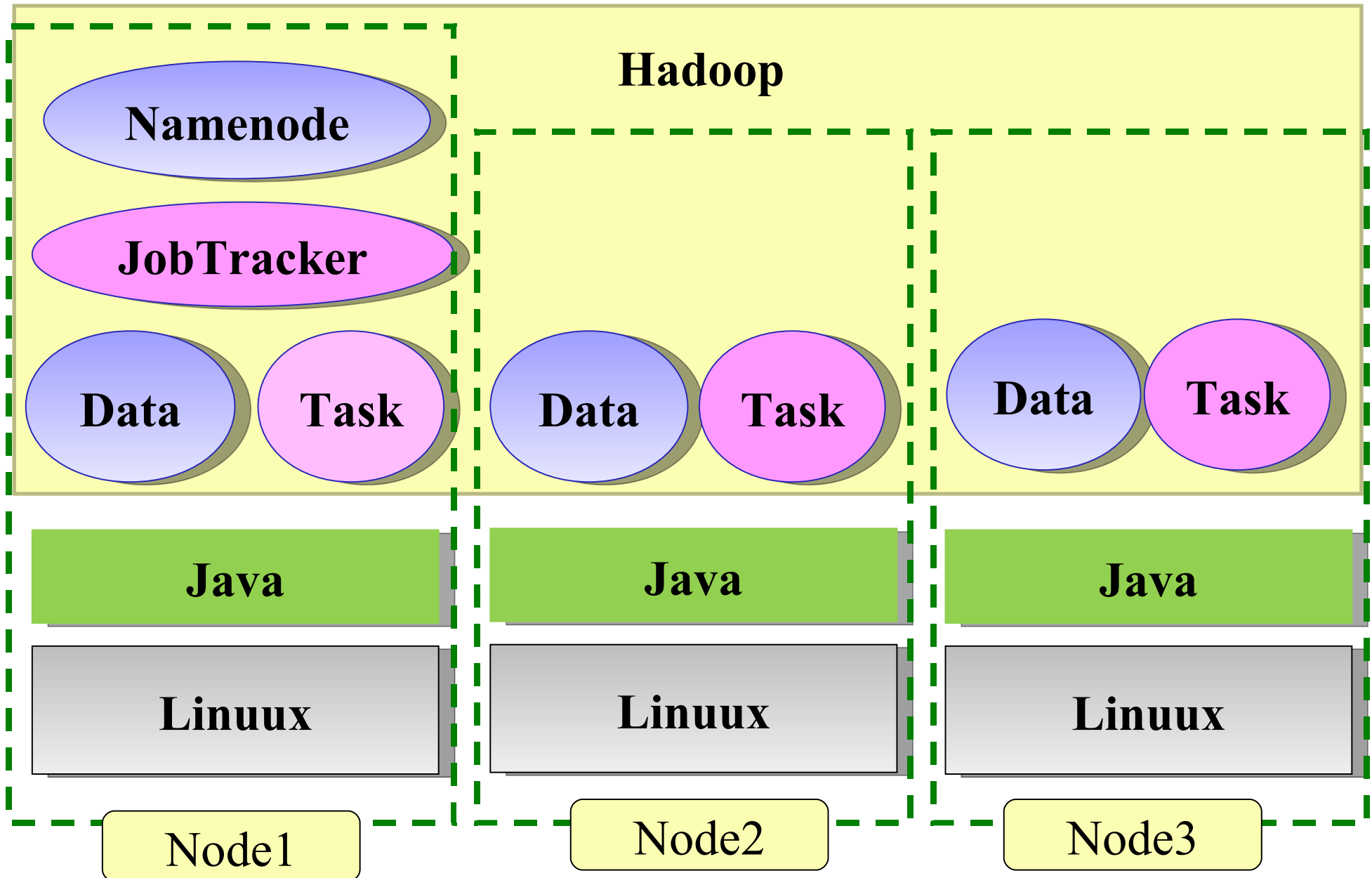
Different Roles of Hadoop Architecture

Hadoop 軟體架構中的不同角色



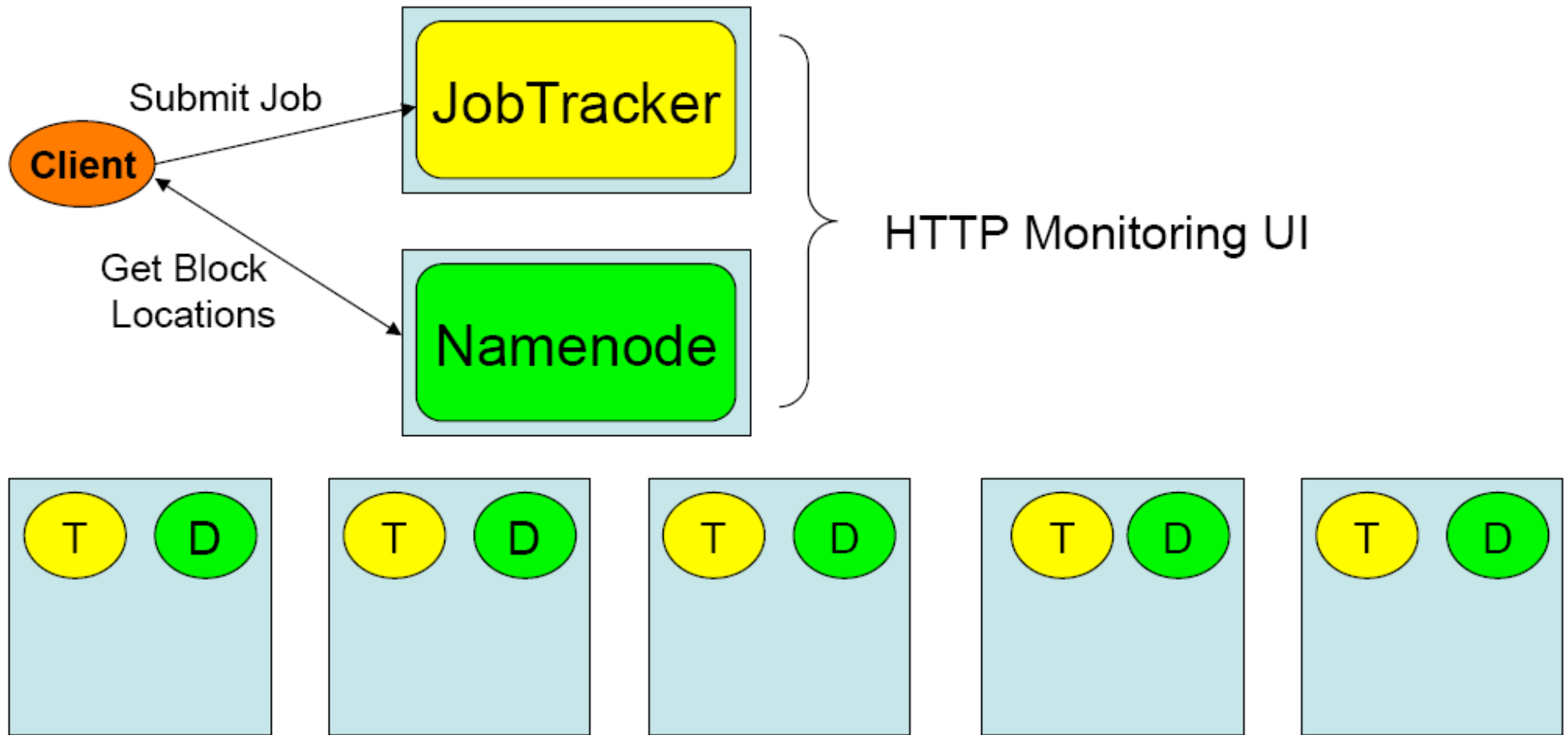
Distributed Operating System of Hadoop

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

採用自由軟體也能打造私有雲端

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**