Hadoop 進階課程

HBase 資料庫應用

< V 0.20 >

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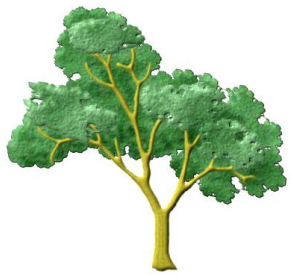


一、導論

原本我們使用關聯式資料庫好好的，為何又要有新資料庫的儲存架構型態，是有其必要？或新技術可完全取而代之？還是只是一個等待泡沫化新技術的濫觴？

海量資料緒論

- Hadoop 能運算海量資料，然後呢？
  - 其實 Hadoop運算出來的結果也不少
- 如何處理 Hadoop 運算出來的資料？
  - 再用Hadoop運算一次??
- 海量資料也需要整理
  - 排序
  - 搜尋
  - 選擇

RDBMS / 資料庫

- **Relational DataBase Management System =** 關聯式資料庫管理系統
  - **Oracle、IBM DB2、SQL Server、MySQL…**

資料庫管理系統（DBMS）（檢視 · 討論 · 編輯 · 歷史）

概念

資料庫 · 資料庫模型 · 資料庫儲存結構 · 關聯 (資料庫) · 關聯模型 · 分布式資料庫 · ACID · Null值
關聯式資料庫 · 關聯代數 · 關聯演算 · 元組關聯演算 · 域關聯演算 · 資料庫正規化 · 參照完整性 · 關聯式資料庫管理系統
主鍵 · 外來鍵 · 代理鍵 · 超鍵 · 候選鍵

資料庫元件

觸發器 · 檢視 · 資料庫表 · 指標 (資料庫) · 事務日誌 · 資料庫事務 · 資料庫索引
儲存程式 · 資料庫分割

SQL

分類： 資料查詢語言DQL · 資料定義語言DDL · 資料操縱語言DML · 資料控制語言DCL
指令：SELECT · INSERT · UPDATE · MERGE · DELETE · JOIN · UNION · CREATE · DROP · Begin work · COMMIT · ROLLBACK · TRUNCATE · ALTER
安全： SQL資料隱碼攻擊 · 參數化查詢

資料庫管理系統的實施

實施型式

關聯式資料庫 · 檔案型資料庫 · Deductive · 維度化資料庫 · 階層式 · 物件資料庫 · 物件關聯式資料庫 · Temporal · XML資料庫

資料庫產品

物件型 (對比) · 關聯型 (對比)

資料庫成分

查詢語言 · 查詢最佳化器 · 查詢計畫 · 嵌入式SQL · ODBC · JDBC · OLE DB

RDBMS 碰上大資料

- RDBMS 的好處
  - 提供了很多而且很豐富的操作方式
  - SQL語法普遍被使用
- 但當資料量愈來愈大時，會遇到單台機器的”囧”境
  - 網路頻寬有限
  - 空間有限
- 走向多台機器架構

跨足多台機器的 RDBMS

- 讀取的 query 比寫入的 query 多
  - **Replication**
- slave 過多時，造成每台記憶體內重複 cache 相同元素
  - **Memcached**
- 寫入的 query 超過單台可以負荷的量時，replication 技術則導致每台Slave 一起掛
  - **Sharding**
  - 依照 id，把資料拆散到各台 （如 Flickr）

多台機器的 RDBMS的缺點

- 需要 application server 或是 library配合，否則第三方程式找不到資料放在哪個node
- 無法隨意使用 JOIN 及 transaction，即使可以硬要使用效能也很差
- 設計 schema 時必須注意，當一個 cluster 愈來愈大時要 rebalance

是否非RDBMS不可？

- Web 2.0 網站很多時候
  - 不需要transaction
  - 減少JOIN 次數
  - 多次 SELECT 拉資料
- 一開始寫在一台DB主機的SQL程式無法再套用於後來多台SQL主機的架構上
  - 程式有可能全部重寫

將RDBMS簡化吧

- RDBMS -> key-value DataBase
  - 簡化掉不需要的功能，到只剩下key-value的架構
    - GET(key)
    - SET(key, value)
    - DELETE(key)
- 類似 Excel

Distributed key-value System

- key-value DataBase -> Distributed key-value DataBase
- 加強 key-value 架構的 scalability，使得增加機器就可以增加容量與頻寬
- 適合管理大量分散於不同主機的資料
- 通稱為 NoSQL DataBase

常見的 NoSQL

OpenSource

- HBase (Yahoo!)
- Cassandra (Facebook)
- MongoDB
- CouchDB (IBM)
- SimpleDB (Amazon)

Commercial

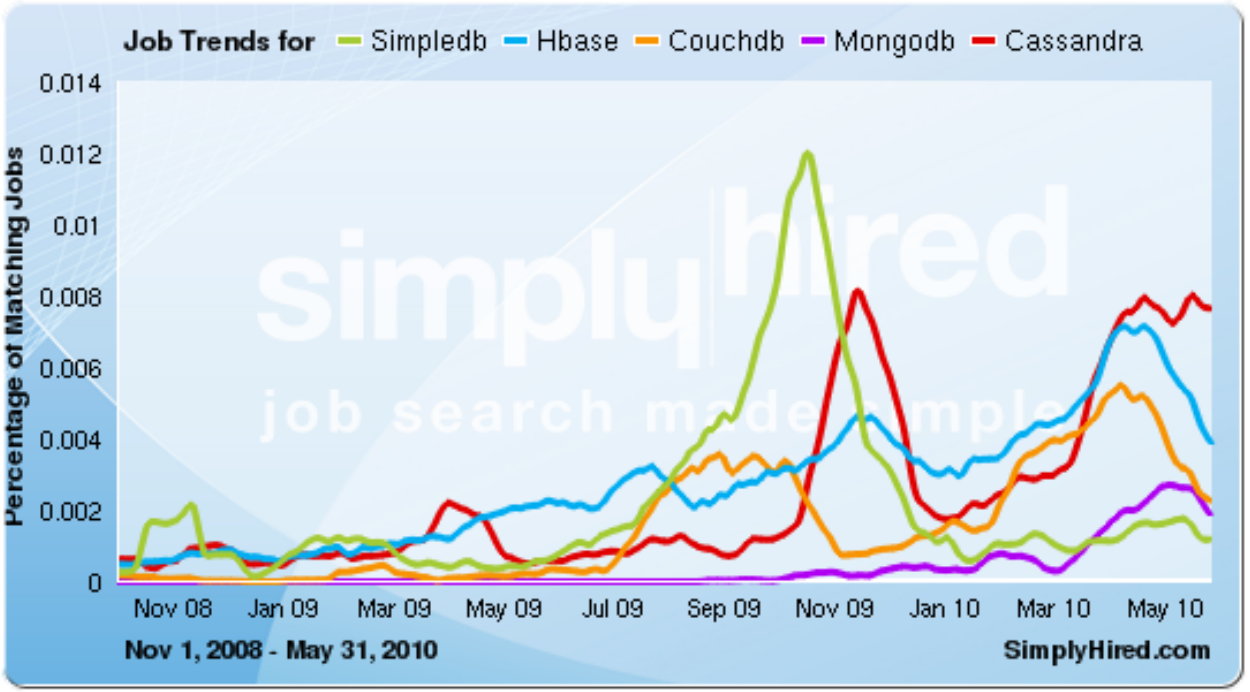
- BigTable (Google)

2010 年 NoSQL 職缺排行榜

1. Cassandra
2. HBase
3. CouchDB
4. MongoDB
5. SimpleDB

(2010-07-25)

Simpledb, Hbase, Couchdb, Mongodb, Cassandra Trends



Simpledb, Hbase, Couchdb, Mongodb, Cassandra 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:

- Simpledb jobs increased 357%
- Hbase jobs increased 745%
- Couchdb jobs did not change or there is no data available
- Mongodb jobs increased 18,480%
- Cassandra jobs did not change or there is no data available

一、HBase 介紹

介紹HBase如何而來，它的 Why, What, How ….，以及它的架構

HBase, *Hadoop database*, is an open-source, distributed, versioned, column-oriented store modeled after Google' Bigtable. Use it when you need random, realtime read/write access to your Big Data.

BigTable ?

- Bigtable: 一個結構化數據的分佈式存儲系統
- Google Style的數據庫，使用結構化的文件來存儲數據
- 不支持關聯或是類似於SQL的高級查詢。
- 大規模處理、高容錯性
- PB級的存儲能力
- 每秒數百萬的讀寫操作

HBase

- 設計概念與結構類似Bigtable
- HBase 以 Hadoop 分散式檔案系統 (HDFS) 為基礎，提供類Bigtable 功能
- HBase 是具有以下特點的儲存系統：
  - 類似表格的資料結構 (Multi-Dimensional Map)
  - 分散式
  - 高可用性、高效能
  - 很容易擴充容量及效能
- HBase 適用於利用數以千計的一般伺服器上，來儲存Petabytes級的資料。
- HBase同時提供Hadoop MapReduce程式設計。

開發歷程

- 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
- 2010.3
  - HBase graduates from Hadoop sub-project to Apache Top Level Project
- 2010.7
  - HBase 0.20.6 released

誰使用 HBase

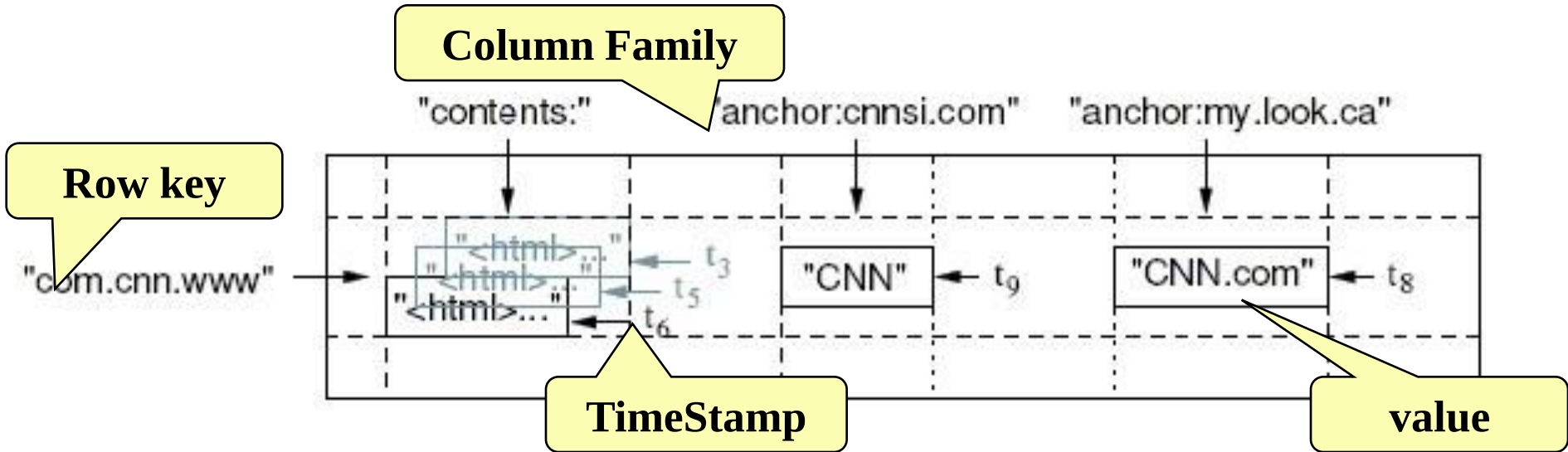
- Adobe
  - 內部使用 (Structure data)
- Kalooga
  - 圖片搜尋引擎 http://www.kalooga.com/
- Meetup
  - 社群聚會網站 http://www.meetup.com/
- Streamy
  - 成功從 MySQL 移轉到 Hbase http://www.streamy.com/
- Trend Micro
  - 雲端掃毒架構 http://trendmicro.com/
- Yahoo!
  - 儲存文件 fingerprint 避免重複 http://www.yahoo.com/
- More
  - http://wiki.apache.org/hadoop/Hbase/PoweredBy

為什麼使用HBase?

- 不是關聯式(Relational)資料庫系統
  - 表格(Table)只有一個主要索引 (primary index) 即 row key.
  - 不提供 join
  - 不提供 SQL語法。
- 提供Java函式庫, 與 REST與Thrift等介面。
- 提供 getRow(), Scan() 存取資料。
  - getRow()可以取得一筆row range的資料，同時也可以指定版本 (timestamp)。
- Scan()可以取得整個表格的資料或是一組row range (設定start key, end key)
- 有限的單元性(Atomicity)與交易 (transaction)功能.
- 只有一種資料型態 (bytes)
- 可以配合MapReduce框架，進行複雜的分析與查詢

Data Model

- Table依 *row key* 來自動排序
- Table schema 只要定義 *column families* .
  - 每個column family 可有無限數量的 columns
  - 每個column的值可有無限數量的時間版本(timestamp)
  - Column可以動態新增，每個row可有不同數量的columns。
  - 同一個column family的columns會群聚在一個實體儲存單元上，且依 column 的名稱排序。
  - byte[] 是唯一的資料型態(Row, Family: Column, Timestamp) Value



Data Model

- HBase實際上儲存Table時，是以column family為單位來存放

Row Key	Time Stamp	Column (Family) "content:"
com.cnn.www	t9	"<html>…"
	t6	"<html>…"

Row Key	Time Stamp	Column (Family) "anchor:"	
com.cnn.www	t9	"anchor:cnnsi.com"	"CNN"
	t8	"anchor:cnnsi.com"	"CNN"
		"anchor:my.loc	"MyLook"

HTable 成員

Table, Family, Column, Qualifier , Row, TimeStamp

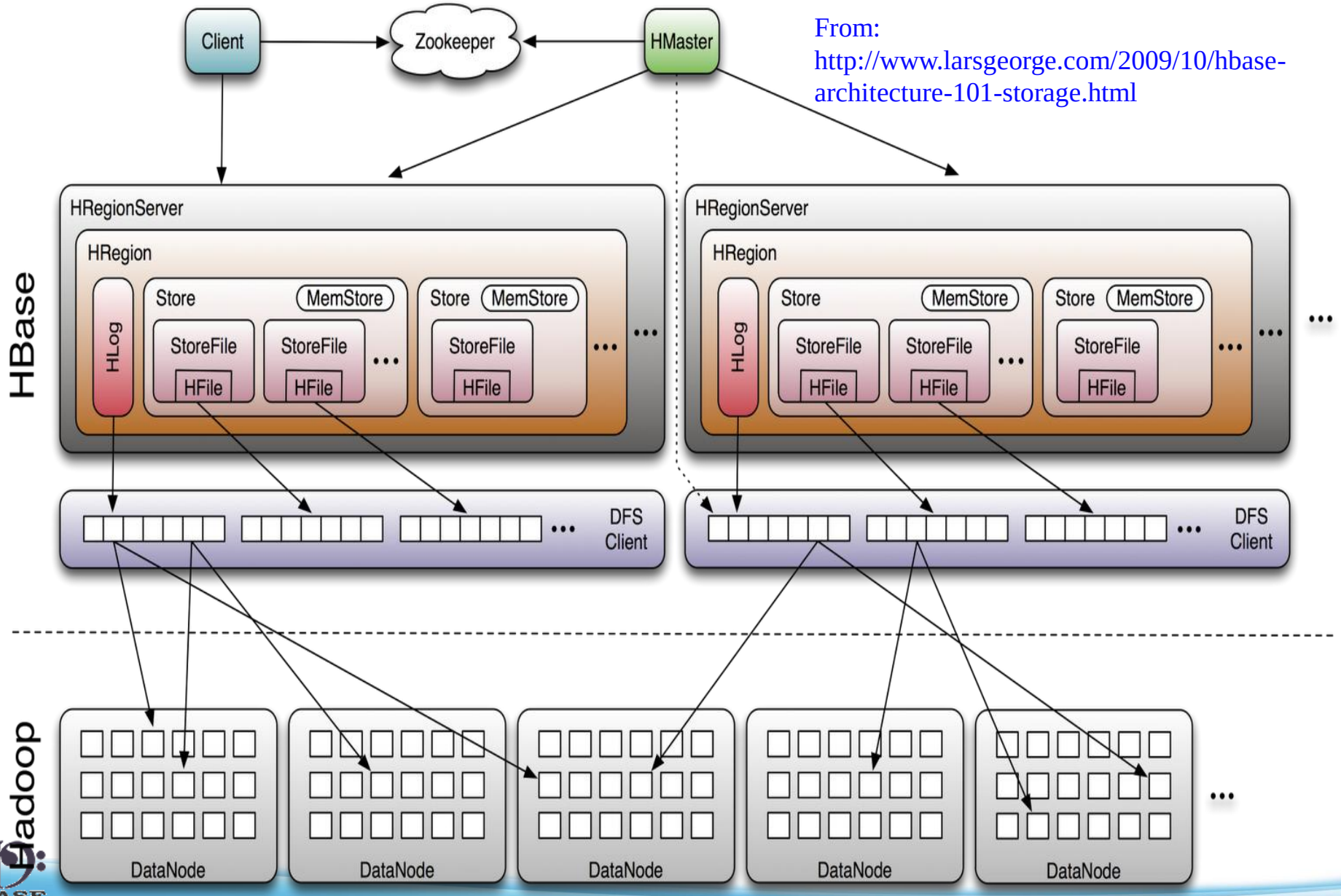
		Contents	Department		
			news	bid	sport
t1	com.yahoo.news.tw	“撿到學雜費，硬要分三成”	“tech”		
t2		“科研論文評比 5校進500大”	“tech”		
t3		“罰蹲立300下！班長「住院」 師懊悔”	“tech”		
t1	com.yahoo.bid.tw	“… iphone 4G 9/17 日上市”		“ 3C ”	
t1	com.yahoo.sport.tw	“Nadal 大滿貫”			“MBA”

Regions

- 表格是由一或多個 region 所構成
  - Region 是由其 startKey 與 endKey 所指定
- 每個 region 可能會存在於多個不同節點上，而且是由數個HDFS 檔案與區塊所構成，這類 region 是由 Hadoop 負責複製

Region	Row Keys	Column Family "Content"
Region 1	00000	…
	00001	…
	…	…
	09999	…
Region 2	10000	…
	…	…
	…	…
	29999	…

HBase 與 Hadoop 搭配的架構

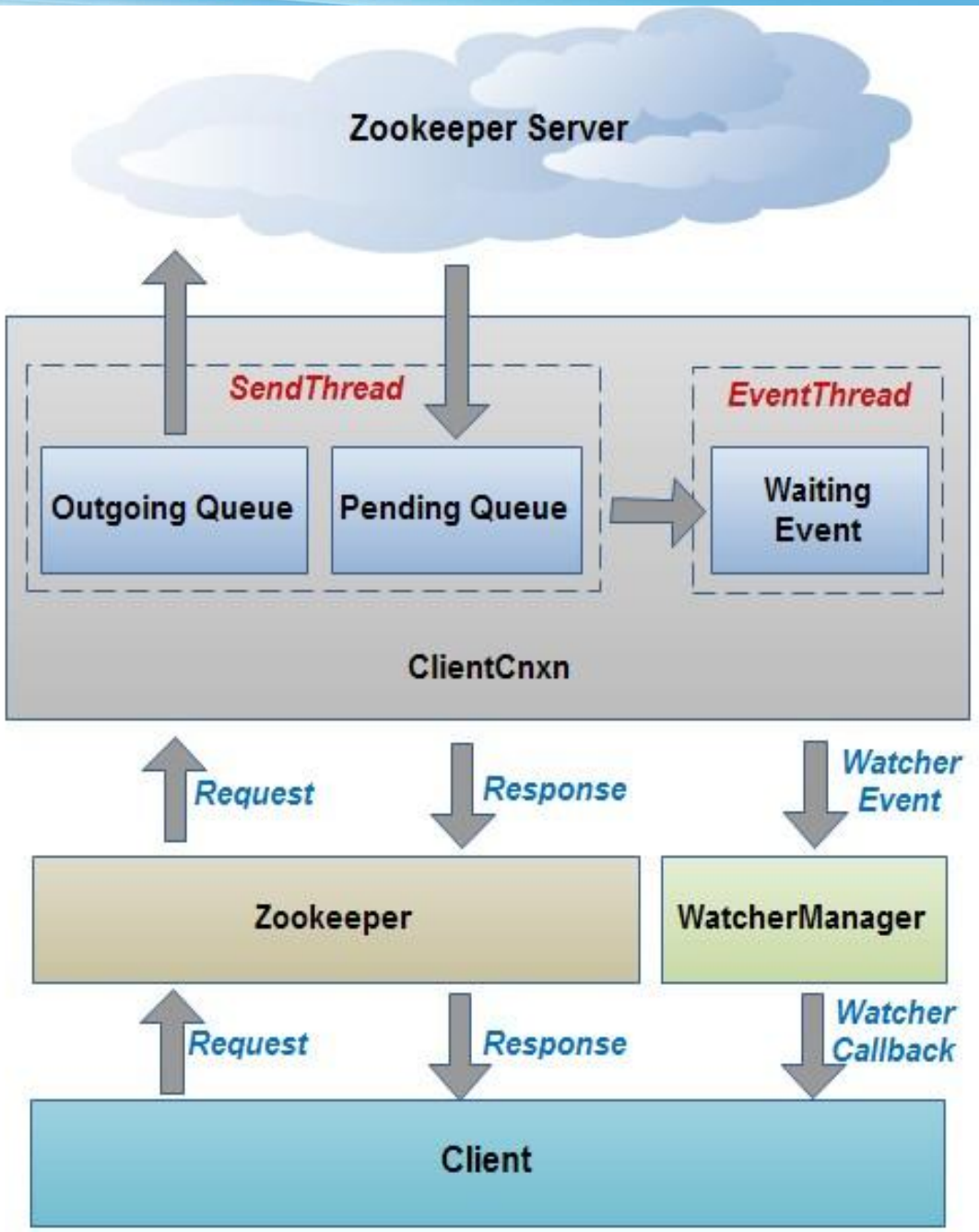


HBase 0.20 特色

- 解決單點失效問題（single point of failure）
  - Ex: Hadoop NameNode failure
- 設定檔改變或小版本更新會重新啟動
- 隨機讀寫（Random access）效能如同MySQL

Zookeeper ?

- Hadoop的正式子項目
- 針對大型分散式系統的可靠協調系統
- Google的Chubby
- 存儲一些配置信息,確保文件寫入的一致性等
- Master / Client 架構，Master 可由選舉而得



From: http://www.spnguru.com/?p=211

二、HBase 安裝說明

安裝

需先安裝過 Hadoop…

```
$ wget
  http://ftp.twaren.net/Unix/Web/apache/hadoop/hbase/hbase-
  0.20.6/hbase-0.20.6.tar.gz
  $ sudo tar -zxvf hbase-*.tar.gz -C /opt/
  $ sudo ln -sf /opt/hbase-0.20.6 /opt/hbase
  $ sudo chown -R $USER:$USER /opt/hbase
```

系統環境設定

$ vim */opt/hbase/conf/hbase-env.sh*

```
# 基本設定
export JAVA_HOME=/usr/lib/jvm/java-6-sun
export HADOOP_HOME=/opt/hadoop
export HBASE_HOME=/opt/hbase
export HBASE_LOG_DIR=/var/hadoop/hbase-logs
export HBASE_PID_DIR=/var/hadoop/hbase-pids
export HBASE_CLASSPATH=$HBASE_CLASSPATH:/opt/hadoop/conf
```

```
# 叢集選項
export HBASE_MANAGES_ZK=true
```

服務參數設定

```
<configuration>
        <property>
          <name> name </name>
          <value> value </value>
        </property>
</configuration>
```

Name	value
hbase.rootdir	hdfs://localhost:9000/hbase
hbase.tmp.dir	/var/hadoop/hbase-${user.name}
hbase.cluster.distributed	true
hbase.zookeeper.property.clientPort	2222
hbase.zookeeper.quorum	Host1, Host2
hbase.zookeeper.property.dataDir	/var/hadoop/hbase-data

停止與啟動服務

需先啟動 Hadoop…

- 全部啟動/關閉

```
$ bin/start-hbase.sh
$ bin/stop-hbase.sh
```

- 個別啟動/關閉

```
$ bin/hbase-daemon.sh start/stop zookeeper
$ bin/hbase-daemon.sh start/stop master
$ bin/hbase-daemon.sh start/stop regionserver
$ bin/hbase-daemon.sh start/stop thrif
$ bin/hbase-daemon.sh start/stop rest
```

測試

```
$ hbase shell
> create 'test', 'data'
0 row(s) in 4.3066 seconds
> list
test
1 row(s) in 0.1485 seconds
> put 'test', 'row1', 'data:1',
        'value1'
0 row(s) in 0.0454 seconds
> put 'test', 'row2', 'data:2',
        'value2'
0 row(s) in 0.0035 seconds
> put 'test', 'row3', 'data:3',
        'value3'
0 row(s) in 0.0090 seconds
```

```
> scan 'test'
ROW COLUMN+CELL
row1 column=data:1, timestamp=1240148026198,
        value=value1
row2 column=data:2, timestamp=1240148040035,
        value=value2
row3 column=data:3, timestamp=1240148047497,
        value=value3
3 row(s) in 0.0825 seconds
> disable 'test'
09/04/19 06:40:13 INFO client.HBaseAdmin: Disabled test
0 row(s) in 6.0426 seconds
> drop 'test'
09/04/19 06:40:17 INFO client.HBaseAdmin: Deleted test
0 row(s) in 0.0210 seconds
> list
0 row(s) in 2.0645 seconds
```

連線到 HBase 的方法

- Java client
  - *get(byte [] row, byte [] column, long timestamp, int versions);*
- Non-Java clients
  - Thrift server hosting HBase client instance
- Sample ruby, c++, & java (via thrift) clients
  - REST server hosts HBase client
- TableInput/OutputFormat for MapReduce
  - HBase as MR source or sink
- HBase Shell
  - JRuby IRB with “DSL” to add get, scan, and admin
  - *./bin/hbase shell YOUR_SCRIPT*

三、HBase 程式設計

3.1 程式編譯方法

3.2 Coding & API

3.2.1 常用的 API 說明

3.2.2 實做 I/O 操作

3.2.3 搭配Map Reduce 運算

3.2.4 進階補充

3.3 案例演練

三、HBase 程式設計

3.1 HBase 程式編譯方法

此篇介紹兩種編譯與執行HBase程式的方法：

Method A – 使用Java JDK 1.6

Method B – 使用Eclipse 套件

A. Java 之編譯與執行

1. 將hbase_home目錄內的 .jar檔全部拷貝至 hadoop_home/lib/ 資料夾內
2. 編譯
   - javac △ -classpath △ **hadoop-*-core.jar:hbase-*.jar** △ -d △ MyJava △ MyCode.java
3. 封裝
   - jar △ -cvf △ MyJar.jar △ -C △ MyJava △ .
4. 執行
   - bin/hadoop △ jar △ MyJar.jar △ MyCode △ {Input/ △ Output/ }

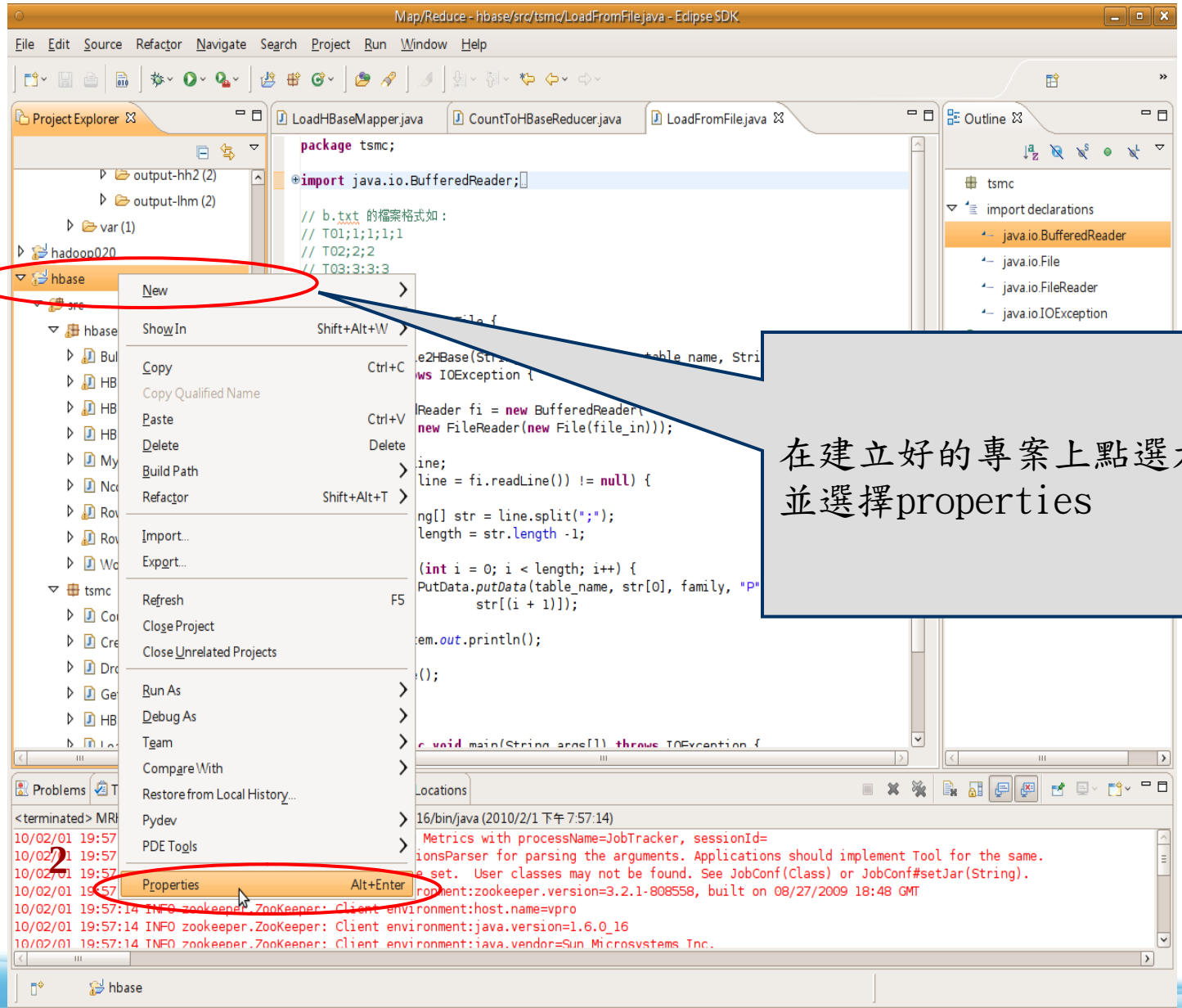
- 所在的執行目錄為Hadoop_Home
- ./MyJava = 編譯後程式碼目錄
- Myjar.jar = 封裝後的編譯檔

- 先放些文件檔到HDFS上的input目錄
- ./input; ./ouput 不一定為 hdfs的輸入、輸出目錄

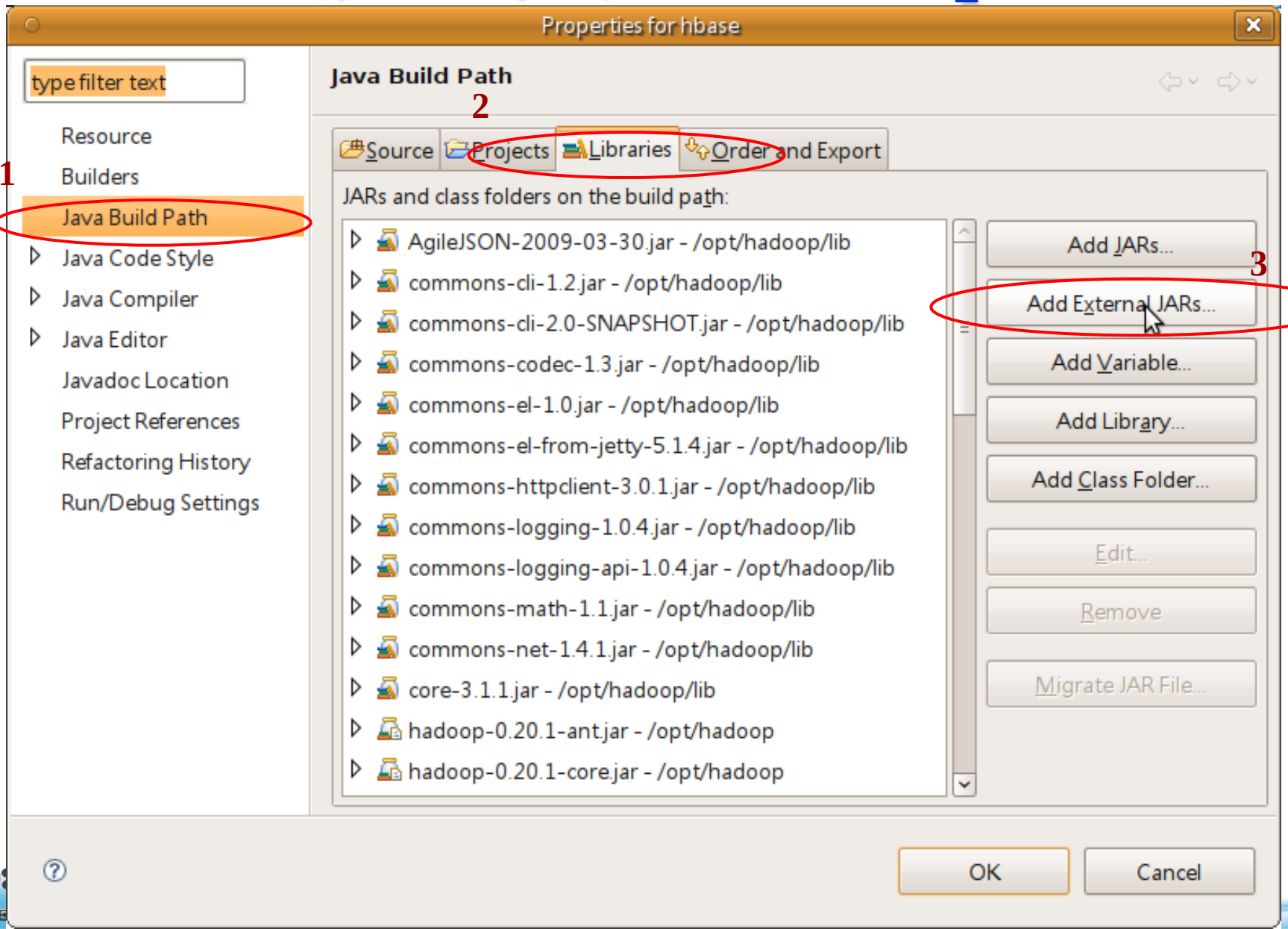
B Eclipse 之編譯與執行

- HBase 已可以於Hadoop上正常運作
- 請先設定好Eclipse 上得 Hadoop 開發環境
  - 可參考附錄
  - Hadoop更詳細說明請參考另一篇 Hadoop 0.20 程式設計
- 建立一個hadoop的專案

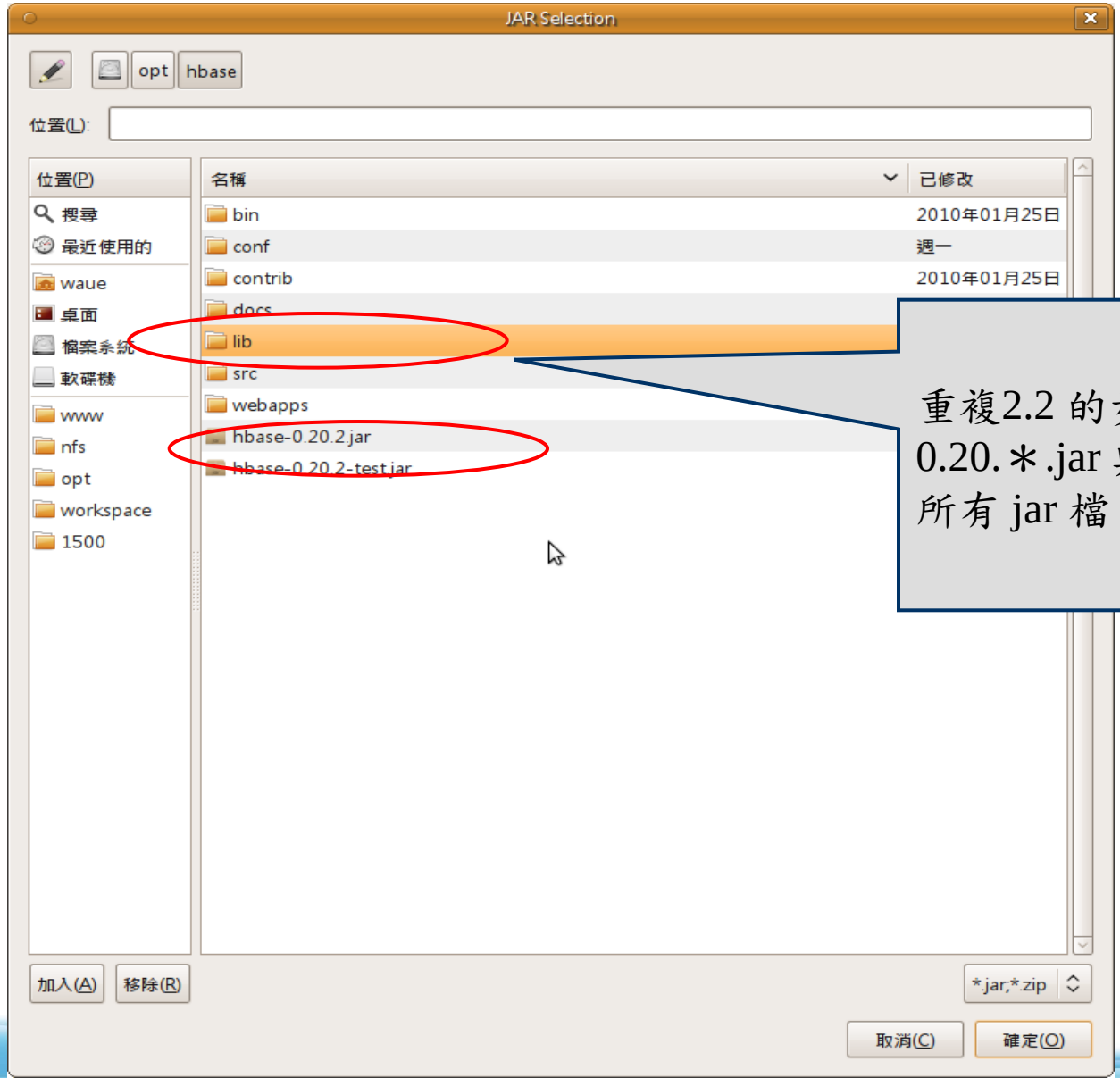
B.1 設定專案的細部屬性



B.2 增加 專案的 Classpath

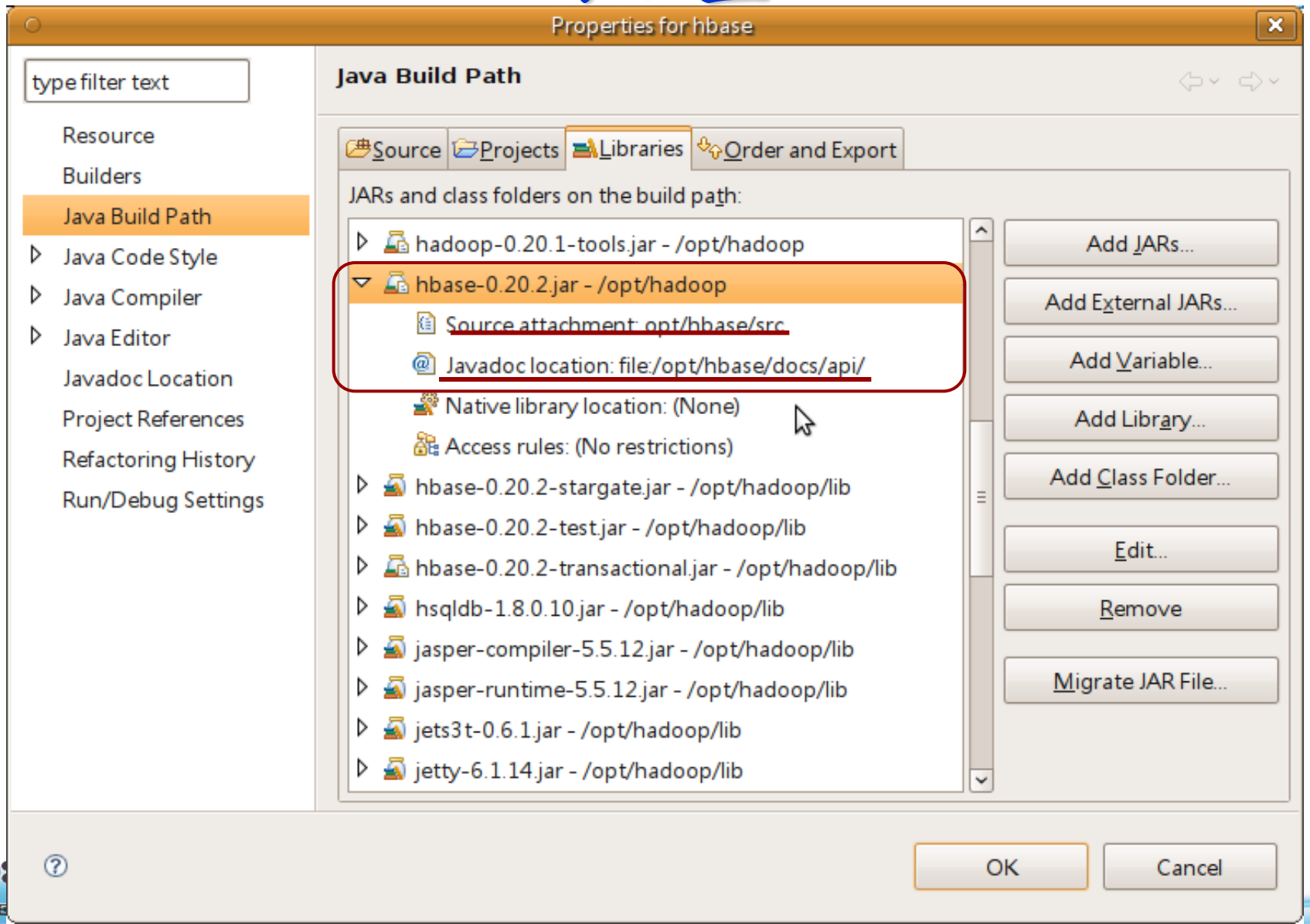


B.3 選擇classpath 的library



重複2.2 的步驟來選取 hbase-0.20.＊.jar 與 lib/資料夾內的所有 jar 檔

B.4 為函式庫增加原始碼、說明檔的配置



三、 HBase 程式設計

3.2.1 常用的 HBase API 說明

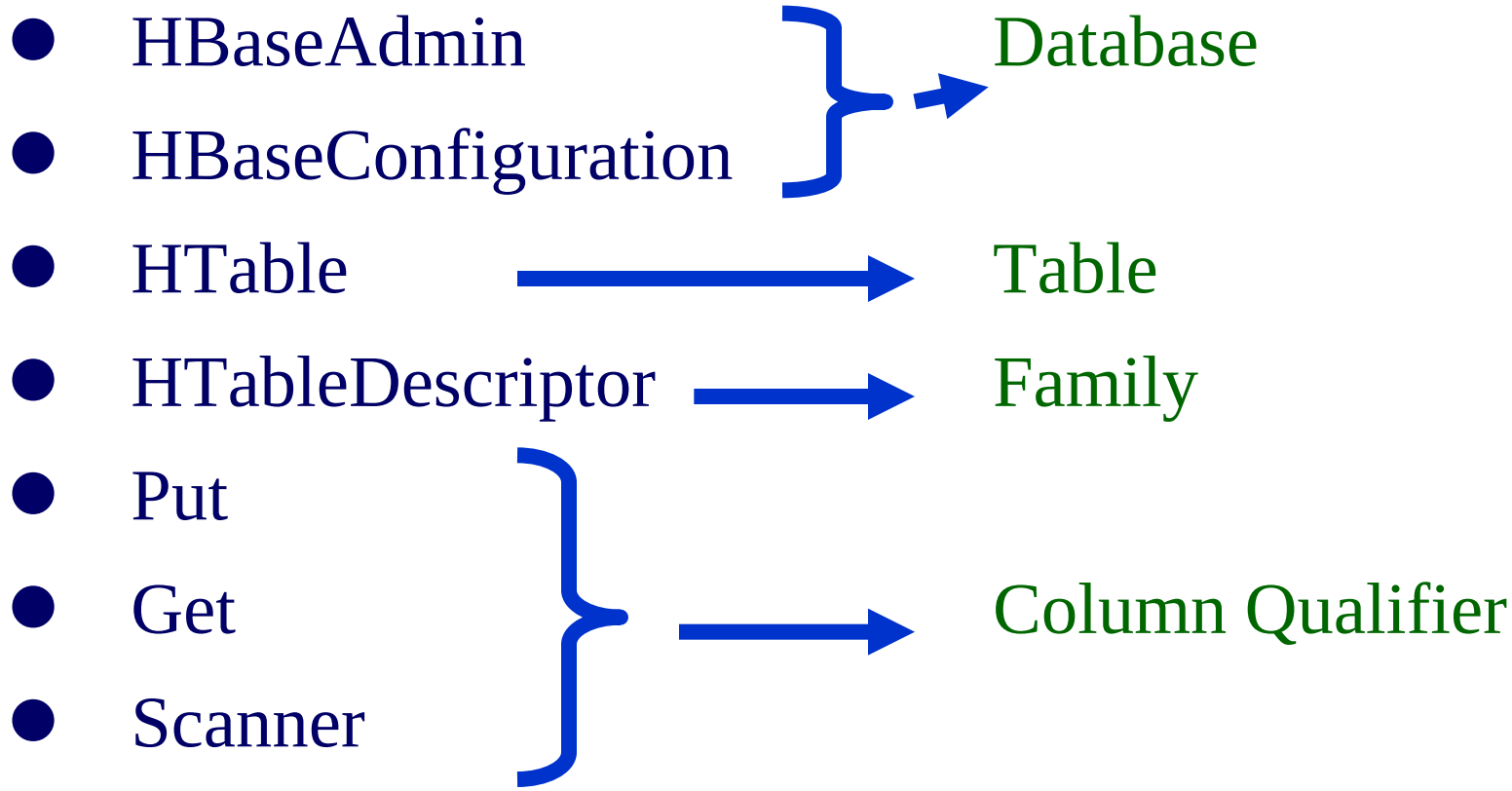
此篇列出用Java寫HBase 程式，常用到的API與說明

HTable 成員

Table, Family, Column, Qualifier , Row, TimeStamp

		Contents	Department		
			news	bid	sport
t1	com.yahoo.news.tw	“我研發水下6千公尺機器人”	“tech”		
t2		“蚊子怎麼搜尋人肉”	“tech”		
t3		“用腦波「發聲」”	“tech”		
t1	com.yahoo.bid.tw	“… ipad …”		“ 3C ”	
t1	com.yahoo.sport.tw	“… Wang 40…”			“MBA”

HBase 常用函式


HBaseAdmin
HBaseConfiguration
Database
HTable
Table
HTableDescriptor
Family
Put
Get
Scanner
Column Qualifier

HBaseConfiguration

- Adds HBase configuration files to a Configuration
  - = new HBaseConfiguration ( )
  - = new HBaseConfiguration (Configuration c)
- 繼承自 org.apache.hadoop.conf.Configuration

```
<property>
  <name> name
  </name>
   <value> value
  </value>
</property>
```

回傳值	函數	參數
void	addResource	(Path file)
void	clear	()
String	get	(String name)
String	getBoolean	(String name, boolean defaultValue)
void	set	(String name, String value)
void	setBoolean	(String name, boolean value)

HBaseAdmin

- HBase的管理介面
  - = new HBaseAdmin(HBaseConfiguration conf)
- Ex:

```
HBaseAdmin admin = new HBaseAdmin(config);
admin.disableTable (“tablename”);
```

回傳值	函數	參數
void	addColumn	(String tableName, HColumnDescriptor column)
	checkHBaseAvailable	(HBaseConfiguration conf)
	createTable	(HTableDescriptor desc)
	deleteTable	(byte[] tableName)
	deleteColumn	(String tableName, String columnName)
	enableTable	(byte[] tableName)
	disableTable	(String tableName)
HTableDescriptor[]	listTables	()
void	modifyTable	(byte[] tableName, HTableDescriptor htd)
boolean	tableExists	(String tableName)

HTableDescriptor

- HTableDescriptor contains the name of an HTable, and its column families.
  - = new HTableDescriptor()
  - = new HTableDescriptor(String name)
- Constant-values
  - org.apache.hadoop.hbase.HTableDescriptor.TABLE_DESCRIPTOR_VERSION
- Ex:

```
HTableDescriptor htd = new HTableDescriptor(tablename);
htd.addFamily ( new HColumnDescriptor (“Family”));
```

回傳值	函數	參數
void	addFamily	(HColumnDescriptor family)
HColumnDescriptor	removeFamily	(byte[] column)
byte[]	getName	( ) = Table name
byte[]	getValue	(byte[] key) = 對應key的value
void	setValue	(String key, String value)

HColumnDescriptor

- An HColumnDescriptor contains information about a column family
  - = new HColumnDescriptor(String familyname)
- Constant-values
  - org.apache.hadoop.hbase.HTableDescriptor.TABLE_DESCRIPTOR_VERSION
- Ex:

```
HTableDescriptor htd = new HTableDescriptor(tablename);
HColumnDescriptor col = new HColumnDescriptor("content:");
htd.addFamily(col);
```

回傳值	函數	參數
byte[]	getName	( ) = Family name
byte[]	getValue	(byte[] key) = 對應key的value
void	setValue	(String key, String value)

HTable

- Used to communicate with a single HBase table.
  - = new HTable(HBaseConfiguration conf, String tableName)
- Ex:

```
HTable table = new HTable (conf, Bytes.toBytes ( tablename ));
ResultScanner scanner = table.getScanner ( family );
```

回傳值	函數	參數
void	checkAndPut	(byte[] row, byte[] family, byte[] qualifier, byte[] value, Put put)
void	close	()
boolean	exists	(Get get)
Result	get	(Get get)
byte[][]	getEndKeys	()
ResultScanner	getScanner	(byte[] family)
HTableDescriptor	getTableDescriptor	()
byte[]	getTableName	()
static boolean	isTableEnabled	(HBaseConfiguration conf, String tableName)
void	put	(Put put)

Put

- Used to perform Put operations for a single row.
  - = new Put(byte[] row)
  - = new Put(byte[] row, RowLock rowLock)
- Ex:

```
HTable table = new HTable (conf, Bytes.toBytes ( tablename ));
Put p = new Put ( brow );
p.add (family, qualifier, value);
table.put ( p );
```

Put	add	(byte[] family, byte[] qualifier, byte[] value)
Put	add	(byte[] column, long ts, byte[] value)
byte[]	getRow	()
RowLock	getRowLock	()
long	getTimeStamp	()
boolean	isEmpty	()
Put	setTimeStamp	(long timestamp)

Get

- Used to perform Get operations on a single row.
  - = new Get (byte[] row)
  - = new Get (byte[] row, RowLock rowLock)
- Ex:

```
HTable table = new HTable(conf, Bytes.toBytes(tablename));
Get g = new Get(Bytes.toBytes(row));
```

Get	addColumn	(byte[] column)
Get	addColumn	(byte[] family, byte[] qualifier)
Get	addColumns	(byte[][] columns)
Get	addFamily	(byte[] family)
TimeRange	getTimeRange	()
Get	setTimeRange	(long minStamp, long maxStamp)
Get	setFilter	(Filter filter)

Result

- Single row result of a Get or Scan query.
  - = new Result()
- Ex:

```
HTable table = new HTable(conf, Bytes.toBytes(tablename));
Get g = new Get(Bytes.toBytes(row));
Result rowResult = table.get(g);
Bytes[] ret = rowResult.getValue( (family + ":"+ column ) );
```

boolean	containsColumn	(byte[] family, byte[] qualifier)
NavigableMap <byte[],byte[]>	getFamilyMap	(byte[] family)
byte[]	getValue	(byte[] column)
byte[]	getValue	(byte[] family, byte[] qualifier)
int	Size	()

Scanner

- All operations are identical to **Get**
  - Rather than specifying a single row, an optional startRow and stopRow may be defined.
- If rows are not specified, the Scanner will iterate over all rows.
  - = new Scan ()
  - = new Scan (byte[] startRow, byte[] stopRow)
  - = new Scan (byte[] startRow, Filter filter)

Get	addColumn	(byte[] column)
Get	addColumn	(byte[] family, byte[] qualifier)
Get	addColumns	(byte[][] columns)
Get	addFamily	(byte[] family)
TimeRange	getTimeRange	()
Get	setTimeRange	(long minStamp, long maxStamp)
Get	setFilter	(Filter filter)

Interface ResultScanner

- Interface for client-side scanning. Go to HTable to obtain instances.
  - HTable.getScanner (Bytes.toBytes(family));
- Ex:

```
ResultScanner scanner = table.getScanner (Bytes.toBytes(family));
for (Result rowResult : scanner) {
        Bytes[] str = rowResult.getValue ( family , column );
}
```

void	close	()
Result	next	()

HBase Key/Value 的格式

- org.apache.hadoop.hbase.KeyValue
- getRow(), getFamily(), getQualifier(), getTimestamp(), and getValue().
- The KeyValue blob format inside the byte array is:

<keylength> <valuelength> <key> <value>

- Key 的格式:

< row-length >	< row>	< column-family-length >	< column-family >	< column-qualifier >	< time-stamp >	< key-type >

- Rowlength 最大值為 Short.MAX_SIZE,
- column family length 最大值為 Byte.MAX_SIZE,
- column qualifier + key length 必須小於 Integer.MAX_SIZE.

三、 HBase 程式設計

3.2.2 實做I/O操作

HBase 的 I/O 操作 範例程式碼

範例一：新增Table

〈指令〉

create <表名>, {<family>, ….}

```
$ hbase shell
> create ‘tablename', ‘family1', 'family2', 'family3‘
0 row(s) in 4.0810 seconds
> List
tablename
1 row(s) in 0.0190 seconds
```

範例一：新增Table

〈程式碼〉

```
public static void createHBaseTable ( String tablename, String
    familyname ) throws IOException
  {
    HBaseConfiguration config = new HBaseConfiguration();
    HBaseAdmin admin = new HBaseAdmin(config);
    HTableDescriptor htd = new HTableDescriptor( tablename );
    HColumnDescriptor col = new HColumnDescriptor( familyname );
    htd.addFamily ( col );
    if( admin.tableExists(tablename))
    {    return ()   }
    admin.createTable(htd);
  }
```

範例二：Put資料進Column

〈指令〉

put ‘表名’, ‘列’, ‘column’, ‘值’ , [‘時間’]

```
> put 'tablename','row1', 'family1:qua1', 'value'
0 row(s) in 0.0030 seconds
```

範例二：Put資料進Column<程式碼>

```
static public void putData(String tablename, String row, String family,
        String column, String value) throws IOException {
    HBaseConfiguration config = new HBaseConfiguration();
    HTable table = new HTable(config, tablename);
    byte[] brow = Bytes.toBytes(row);
    byte[] bfamily = Bytes.toBytes(family);
    byte[] bcolumn = Bytes.toBytes(column);
    byte[] bvalue = Bytes.toBytes(value);
    Put p = new Put(brow);
    p.add(bfamily, bcolumn, bvalue);
    table.put(p);
    table.close();
}
```

範例三： Get Column Value

〈指令〉

get ‘表名’ ,‘列’

```
> get 'tablename', 'row1'
COLUMN                CELL
family1:column1       timestamp=1265169495385,   value=value
1 row(s) in 0.0100 seconds
```

範例三： Get Column Value <程式碼>

```
String getColumn ( String tablename, String row, String
    family,  String column )  throws  IOException {
    HBaseConfiguration conf = new HBaseConfiguration();
    HTable table;
    table = new HTable( conf, Bytes.toBytes( tablename));
    Get g = new Get(Bytes.toBytes(row));
    Result rowResult = table.get(g);
    return Bytes.toString( rowResult.getValue (
                Bytes.toBytes (family +   ":"   + column)));
    }
```

範例四： Scan all Column

〈指令〉

scan ‘表名’

```
> scan 'tablename'
ROW   COLUMN+CELL
row1  column=family1:column1, timestamp=1265169415385, value=value1
row2  column=family1:column1, timestamp=1263534411333, value=value2
row3  column=family1:column1, timestamp=1263645465388, value=value3
row4  column=family1:column1, timestamp=1264654615301, value=value4
row5  column=family1:column1, timestamp=1265146569567, value=value5
5 row(s) in 0.0100 seconds
```

範例四：Scan all Column<程式碼>

```
static void ScanColumn(String tablename, String family, String
        column)  throws IOException {
            HBaseConfiguration conf = new HBaseConfiguration();
            HTable table = new HTable ( conf, Bytes.toBytes(tablename));
            ResultScanner scanner = table.getScanner(
                                                    Bytes.toBytes(family));
            int i = 1;
            for (Result rowResult : scanner) {
                    byte[] by = rowResult.getValue(
                            Bytes.toBytes(family), Bytes.toBytes(column) );
                    String str = Bytes.toString ( by );
                    System.out.println("row " + i + " is \"" + str +"\"");
                    i++;
}}}
```

範例五： 刪除資料表

〈指令〉

disable ‘表名’
drop ‘表名’

```
> disable 'tablename'
0 row(s) in 6.0890 seconds
> drop 'tablename'
0 row(s) in 0.0090 seconds
0 row(s) in 0.0090 seconds
0 row(s) in 0.0710 seconds
```

範例五： 刪除資料表 〈程式碼〉

```
static void drop ( String tablename ) throws IOExceptions {
      HBaseConfiguration conf = new HBaseConfiguration();
      HBaseAdmin admin = new HBaseAdmin (conf);
      if (admin.tableExists(tablename))
       {
         admin.disableTable(tablename);
         admin.deleteTable(tablename);
      }else{
         System.out.println(" [" + tablename+ "] not found!");
}}
```

三、 HBase 程式設計

3.2.3 MapReduce與HBase的搭配

HBase 的 MapReduce 範例程式碼

範例六：WordCountHBase

說明：

此程式碼將輸入路徑的檔案內的字串取出做字數統計

再將結果塞回HTable內

運算方法：

將此程式運作在hadoop 0.20 平台上，用(參考2)的方法加入hbase參數後，將此程式碼打包成XX.jar

結果：

```
> scan 'wordcount'
ROW         COLUMN+CELL
am          column=content:count, timestamp=1264406245488, value=1
chen        column=content:count, timestamp=1264406245488, value=1
hi,         column=content:count, timestamp=1264406245488, value=2
```

注意：

1. 在hdfs 上來源檔案的路徑為 "/user/$YOUR_NAME/input"

   請注意必須先放資料到此hdfs上的資料夾內，且此資料夾內只能放檔案，不可再放資料夾

2. 運算完後，程式將執行結果放在hbase的wordcount資料表內

範例六：WordCountHBase <1>

```
public class WordCountHBase
{
   public static class Map extends
        Mapper<LongWritable,Text,Text,
        IntWritable>
   {
      private IntWritable i = new
        IntWritable(1);
      public void map(LongWritable
        key,Text value,Context context)
        throws IOException,
        InterruptedException
      {
         String s[] =
        value.toString().trim().split(" ");
         for( String m : s)
         {
            context.write(new Text(m), i);
}}}
```

```
public static class Reduce extends
        TableReducer<Text, IntWritable,
        NullWritable>  {
      public void reduce(Text key,
        Iterable<IntWritable> values, Context
        context) throws IOException,
        InterruptedException  {
          int sum = 0;
          for(IntWritable i : values) {
              sum += i.get(); }
        Put put = new
        Put(Bytes.toBytes(key.toString()));
          put.add(Bytes.toBytes("content"),
        Bytes.toBytes("count"),
        Bytes.toBytes(String.valueOf(sum)));
          context.write(NullWritable.get(),
        put);
} }
```

範例六：WordCountHBase <2>

```
public static void createHBaseTable(String
        tablename)throws IOException
  {
     HTableDescriptor htd = new
        HTableDescriptor(tablename);
     HColumnDescriptor col = new
        HColumnDescriptor("content:");
     htd.addFamily(col);
     HBaseConfiguration config = new
        HBaseConfiguration();
     HBaseAdmin admin = new
        HBaseAdmin(config);
     if(admin.tableExists(tablename))
     {
        admin.disableTable(tablename);
        admin.deleteTable(tablename);
     }
     System.out.println("create new table: " +
        tablename);
     admin.createTable(htd);
  }
```

```
public static void main(String args[]) throws Exception
{
   String tablename = "wordcount";
   Configuration conf = new Configuration();
   conf.set(TableOutputFormat.OUTPUT_TABLE,
      tablename);
   createHBaseTable(tablename);
   String input = args[0];
   Job job = new Job(conf, "WordCount " + input);
   job.setJarByClass(WordCountHBase.class);
   job.setNumReduceTasks(3);
   job.setMapperClass(Map.class);
   job.setReducerClass(Reduce.class);
   job.setMapOutputKeyClass(Text.class);
   job.setMapOutputValueClass(IntWritable.class);
   job.setInputFormatClass(TextInputFormat.class);
   job.setOutputFormatClass(TableOutputFormat.class);
   FileInputFormat.addInputPath(job, new Path(input));
   System.exit(job.waitForCompletion(true)?0:1);
}}
```

範例七：LoadHBaseMapper

說明：

此程式碼將HBase的資料取出來，再將結果塞回hdfs上

運算方法：

將此程式運作在hadoop 0.20 平台上，用(參考2)的方法加入hbase參數後，將此程式碼打包成XX.jar

結果：

$ hadoop fs -cat <hdfs_output>/part-r-00000

---

54 30 31 GunLong

54 30 32 Esing

54 30 33 SunDon

54 30 34 StarBucks

注意：

1. 請注意hbase 上必須要有 table, 並且已經有資料
2. 運算完後，程式將執行結果放在你指定 hdfs的<hdfs_output> 內
   請注意 沒有 <hdfs_output> 資料夾

範例七：LoadHBaseMapper <1>

```
public class LoadHBaseMapper {
public static class HtMap extends
        TableMapper<Text, Text> {
public void
        map(ImmutableBytesWritable key,
        Result value,
            Context context) throws
        IOException,
        InterruptedException {
        String res =
        Bytes.toString(value.getValue(Byt
        es.toBytes("Detail"),

            Bytes.toBytes("Name")));
        context.write(new
        Text(key.toString()), new
        Text(res));
}}
```

```
public static class HtReduce extends
        Reducer<Text, Text, Text, Text> {
public void reduce(Text key, Iterable<Text>
        values, Context context)
            throws IOException,
        InterruptedException {
        String str = new String("");
        Text final_key = new Text(key);
        Text final_value = new Text();
        for (Text tmp : values) {
            str += tmp.toString();        }
        final_value.set(str);
        context.write(final_key, final_value);
}}
```

範例七：LoadHBaseMapper <2>

```
public static void main(String args[])
        throws Exception {
String input = args[0];
String tablename = "tcrc";
Configuration conf = new
        Configuration();
Job job = new Job (conf, tablename + "
        hbase data to hdfs");
job.setJarByClass
        (LoadHBaseMapper.class);
TableMapReduceUtil.
        initTableMapperJob
(tablename, myScan,
        HtMap.class,Text.class,
        Text.class, job);
job.setMapperClass (HtMap.class);
```

```
job.setReducerClass (HtReduce.class);
job.setMapOutputKeyClass (Text.class);
job.setMapOutputValueClass
        (Text.class);
job.setInputFormatClass (
        TableInputFormat.class);
job.setOutputFormatClass (
        TextOutputFormat.class);
job.setOutputKeyClass( Text.class);
job.setOutputValueClass( Text.class);
FileOutputFormat.setOutputPath ( job,
        new Path(input));
System.exit (job.waitForCompletion
        (true) ? 0 : 1);
}}
```

三、 HBase 程式設計

3.2.4 進階補充

HBase內contrib的項目，如

A. Trancational

B. Thrift

A. Transactional HBase

- Indexed Table = Secondary Index = Transactional HBase
- 內容與原本table 相似的另一張table，但key 不同，利於排列內容

Primary Table

	name	price	description
1	apple	10	xx
2	orig	5	ooo
3	banana	15	vvvv
4	tomato	8	uu

Indexed Table

	name	price	description
2	orig	5	ooo
4	tomato	8	uu
1	apple	10	xx
3	banana	15	vvvv

A.1 Transactional HBase

環境設定

需在 $HBASE_INSTALL_DIR/conf/hbase-site.xml 檔內
增加兩項內容

```
<property>
  <name> hbase.regionserver.class </name>
  <value> org.apache.hadoop.hbase.ipc.IndexedRegionInterface
   </value>
</property>
<property>
  <name> hbase.regionserver.impl </name>
  <value>
org.apache.hadoop.hbase.regionserver.tableindexed.IndexedRegionServer
  </value>
</property>
```

A.a Ex：從一個原有的Table 增加 IndexedTable

```
public void addSecondaryIndexToExistingTable
    (String TableName, String IndexID, String
    IndexColumn) throws IOException {
    HBaseConfiguration conf = new HBaseConfiguration();
    IndexedTableAdmin admin = null;
    admin = new IndexedTableAdmin(conf);
    admin.addIndex(Bytes.toBytes(TableName), new
    IndexSpecification(
            IndexID, Bytes.toBytes(IndexColumn)));
}}
```

A.b Ex：建立一個新的Table 附帶 IndexedTable

```
public void createTableWithSecondaryIndexes(String TableName,
        String IndexColumn) throws IOException {
    HBaseConfiguration conf = new HBaseConfiguration();
    conf.addResource(new Path("/opt/hbase/conf/hbase-site.xml"));
    HTableDescriptor desc = new HTableDescriptor(TableName);
    desc.addFamily(new HColumnDescriptor("Family1"));
    IndexedTableDescriptor Idxdesc = new
    IndexedTableDescriptor(desc);
    Idxdesc.addIndex(new IndexSpecification(IndexColumn, Bytes
            .toBytes(" Family1 :" + IndexColumn)));
    IndexedTableAdmin admin = new IndexedTableAdmin(conf);
    admin.createIndexedTable(Idxdesc);
}
```

B. Thrift

- 由 Facebook 所開發
- 提供跨語言做資料交換的平台
- 你可以用任何 Thrift 有支援的語言來存取 HBase
  - PHP
  - Perl
  - C++
  - Python
  - …..

B.1 安裝方法

- Thrift（0.2 ~ 0.4） + PHP 5 + HBase 0.20
- http://trac.nchc.org.tw/cloud/wiki/waue/2010/HbaseThrift
  - 請先安裝HBase 之後，並用套件安裝工具安裝PHP 相關套件，再用此連結內的教材安裝Thrift

B.2 Thrift 的PHP程式碼

- http://trac.nchc.org.tw/cloud/wiki/waue/2010/HbaseThrift
  - 連線
  - 列出所有table
  - 刪除table
  - 寫入資料
  - 讀取資料
  - Scan 一整張table

三、 HBase 程式設計

3.3 案例演練

利用一個虛擬的案例來運用之前的程式碼

中科餐廳開張囉！

- 故事背景：
  - 中科餐城即將開張，預估有大批人潮
  - 管理局想統計餐城內所有餐廳的營運狀況
- 用傳統資料庫可能：
  - 大規模資料、同時讀寫，資料分析運算、…（自行發揮）
- 因此員工餐廳將導入
  - HBase資料庫存放資料
  - 透過 Hadoop進行Map Reduce分析運算

3.3.1. 建立商店資料

假設：目前有四間商店進駐中科餐廳，分別為位在
第1區的GunLong，品項4項單價為<20,40,30,50>
第2區的ESing,品項1項單價為<50>
第3區的SunDon,品項2項單價為<40,30>
第4區的StarBucks,品項3項單價為<50,50,20>

	Detail		Products				Turnover			
	Name	Locate	P1	P2	P3	P4				
T01	GunLong	01	20	40	30	50				
T02	ESing	02	50							
T03	SunDon	03	40	30						
T04	StarBucks	04	50	50	20					

3.3.1.a 建立初始HTable

〈程式碼〉

```
public void createHBaseTable(String tablename, String[] family)
        throws IOException {
HTableDescriptor htd = new HTableDescriptor(tablename);
for (String fa : family) {
        htd.addFamily(new HColumnDescriptor(fa));
}
HBaseConfiguration config = new HBaseConfiguration();
HBaseAdmin admin = new HBaseAdmin(config);
if (admin.tableExists(tablename)) {
        System.out.println("Table: " + tablename + "Existed.");
} else {
        System.out.println("create new table: " + tablename);

        admin.createTable(htd);
}
}
```

3.3.1.a 執行結果

Table: TCRC

Family	Detail	Products	Turnover
Qualifier	…	…	…
Row1	value		
Row2			
Row3			
…			

3.3.1.b 用讀檔方式把資料匯入HTable

〈程式碼〉

```
void loadFile2HBase(String file_in, String table_name) throws IOException {
BufferedReader fi = new BufferedReader(
            new FileReader(new File(file_in)));
String line;
while ((line = fi.readLine()) != null) {
        String[] str = line.split(";");
        int length = str.length;
        PutData.putData(table_name, str[0].trim(), "Detail", "Name", str[1]
                        .trim());
        PutData.putData(table_name, str[0].trim(), "Detail", "Locate",
                        str[2].trim());
        for (int i = 3; i < length; i++) {
            PutData.putData(table_name, str[0], "Products", "P" + (i - 2),
                                        str[i]);
        }
        System.out.println();
}
fi.close();
}
```

3.3.1.b 執行結果

	Detail		Products				Turnover
	Name	Locate	P1	P2	P3	P4	
T01	GunLong	01	20	40	30	50	
T02	ESing	02	50				
T03	SunDon	03	40	30			
T04	StarBucks	04	50	50	20		

3.3.1. 螢幕輸出結果

```
create new table: tcrc
Put data :"GunLong" to Table: tcrc's Detail:Name
Put data :"01" to Table: tcrc's Detail:Locate
Put data :"20" to Table: tcrc's Products:P1
Put data :"40" to Table: tcrc's Products:P2
Put data :"30" to Table: tcrc's Products:P3
Put data :"50" to Table: tcrc's Products:P4

Put data :"Esing" to Table: tcrc's Detail:Name
Put data :"02" to Table: tcrc's Detail:Locate
Put data :"50" to Table: tcrc's Products:P1

Put data :"SunDon" to Table: tcrc's Detail:Name
Put data :"03" to Table: tcrc's Detail:Locate
Put data :"40" to Table: tcrc's Products:P1
Put data :"30" to Table: tcrc's Products:P2

Put data :"StarBucks" to Table: tcrc's Detail:Name
Put data :"04" to Table: tcrc's Detail:Locate
Put data :"50" to Table: tcrc's Products:P1
Put data :"50" to Table: tcrc's Products:P2
Put data :"20" to Table: tcrc's Products:P3
```

3.3.2 計算單月每個品項的購買次數

- 刷卡購餐的系統將每人每次購餐紀錄成檔案，格式如右
- 讀紀錄檔並統計每天每個品項的消費次數
  - 將檔案上傳至hdfs
  - 使用Hadoop運算
- 計算完後寫入HBase
  - Turnover:P1,P2,P3,P4

```
waue:T01:P1:xx
jazz:T01:P2:xxx
lia:T01:P3:xxxx
hung:T02:P1:xx
lia:T04:P1:xxxx
lia:T04:P1:xxxx
hung:T04:P3:xx
hung:T04:P2:xx

……
```

3.3.2. 用Hadoop的Map Reduce運算並把結果匯入HTable

<map 程式碼>

```
public class tcrc2Count {
public static class HtMap extends
        Mapper<LongWritable, Text, Text,
        IntWritable> {
private IntWritable one = new
        IntWritable(1);
public void map(LongWritable key, Text
        value, Context context)
            throws IOException,
        InterruptedException {
        String s[] =
        value.toString().trim().split(":");
        // xxx:T01:P4:oooo => T01@P4
        String str = s[1] + "@" + s[2];
        context.write(new Text(str), one);
}
}
```

<reduce程式碼>

```
public static class HtReduce extends
        TableReducer<Text, IntWritable,
        LongWritable> {
public void reduce(Text key, Iterable<IntWritable>
        values,
            Context context) throws IOException,
        InterruptedException {
        int sum = 0;
        for (IntWritable i : values) sum += i.get();
        String[] str = (key.toString()).split("@");
        byte[] row = (str[0]).getBytes();
        byte[] family = Bytes.toBytes("Turnover");
        byte[] qualifier = (str[1]).getBytes();
        byte[] summary =
        Bytes.toBytes(String.valueOf(sum));
        Put put = new Put(row);
        put.add(family, qualifier, summary );
        context.write(new LongWritable(), put);
}}
```

3.3.2. 用Hadoop的Map Reduce運算並把結果匯入HTable

< Main 程式碼>

```
public static void main(String args[]) throws Exception {
String input = "income";
String tablename = "tcrc";
Configuration conf = new Configuration();
conf.set(TableOutputFormat.OUTPUT_TABLE, tablename);
Job job = new Job(conf, "Count to tcrc");
job.setJarByClass(tcrc2Count.class);
job.setMapperClass(HtMap.class);
job.setReducerClass(HtReduce.class);
job.setMapOutputKeyClass(Text.class);
job.setMapOutputValueClass(IntWritable.class);
job.setInputFormatClass(TextInputFormat.class);
job.setOutputFormatClass(TableOutputFormat.class);
FileInputFormat.addInputPath(job, new Path(input));
System.exit(job.waitForCompletion(true) ? 0 : 1);
}
}
```

3.3.2 執行結果

	Detail		Products				Turnover			
	Name	Locate	P1	P2	P3	P4	P1	P2	P3	P4
T01	GunLong	01	20	40	30	50	1	1	1	1
T02	ESing	02	50				2			
T03	SunDon	03	40	30			3			
T04	StarBucks	04	50	50	20		2	1	1	

```
> scan 'tcrc'
ROW                    COLUMN+CELL
 T01                   column=Detail:Locate, timestamp=1265184360616, value=01
 T01                   column=Detail:Name, timestamp=1265184360548, value=GunLong
 T01                   column=Products:P1, timestamp=1265184360694, value=20
 T01                   column=Products:P2, timestamp=1265184360758, value=40
 T01                   column=Products:P3, timestamp=1265184360815, value=30
 T01                   column=Products:P4, timestamp=1265184360866, value=50
 T01                   column=Turnover:P1, timestamp=1265187021528, value=1
 T01                   column=Turnover:P2, timestamp=1265187021528, value=1
 T01                   column=Turnover:P3, timestamp=1265187021528, value=1
 T01                   column=Turnover:P4, timestamp=1265187021528, value=1
 T02                   column=Detail:Locate, timestamp=1265184360951, value=02
 T02                   column=Detail:Name, timestamp=1265184360910, value=Esing
 T02                   column=Products:P1, timestamp=1265184361051, value=50
 T02                   column=Turnover:P1, timestamp=1265187021528, value=2
 T03                   column=Detail:Locate, timestamp=1265184361124, value=03
 T03                   column=Detail:Name, timestamp=1265184361098, value=SunDon
 T03                   column=Products:P1, timestamp=1265184361189, value=40
 T03                   column=Products:P2, timestamp=1265184361259, value=30
 T03                   column=Turnover:P1, timestamp=1265187021529, value=3
 T04                   column=Detail:Locate, timestamp=1265184361311, value=04
 T04                   column=Detail:Name, timestamp=1265184361287, value=StarBucks
 T04                   column=Products:P1, timestamp=1265184361343, value=50
 T04                   column=Products:P2, timestamp=1265184361386, value=50
 T04                   column=Products:P3, timestamp=1265184361422, value=20
 T04                   column=Turnover:P1, timestamp=1265187021529, value=2
 T04                   column=Turnover:P2, timestamp=1265187021529, value=1
 T04                   column=Turnover:P3, timestamp=1265187021529, value=1
4 row(s) in 0.0310 seconds
```

3.3.3. 計算當天營業額

- 計算每間商店的營業額
  - Σ（<該項商品單價> X <被購買的次數>）
  - 透過 Hadoop 的Map () 從HBase內的 Products:{P1,P2,P3,P4} 與 Turnover:{P1,P2,P3,P4} 調出來
  - 經過計算後由Hadoop 的Reduce () 寫回 HBase 內 Turnover:Sum 的Column內
    - 需考慮到表格內每家的商品數量皆不同、有的品項沒有被購買

3.3.3. Hadoop 來源與輸出皆為 HBase

<map 程式碼>

```
public class tcrc3CalculateMR {
public static class HtMap extends TableMapper<Text, Text> {
public void map(ImmutableBytesWritable key, Result value,
        Context context) throws IOException, InterruptedException {
String row = Bytes.toString(value.getValue(Bytes.toBytes("Detail"),
            Bytes.toBytes("Locate")));
int sum = 0;
for (int i = 0; i < 4; i++) {
        String v = Bytes.toString(value.getValue(Bytes
                        .toBytes("Products"), Bytes.toBytes("P" + (i +
        1))));
        String c = Bytes.toString(value.getValue(Bytes
                        .toBytes("Turnover"), Bytes.toBytes("P" + (i +
        1))));
        if (v != null ) {
            if(c == null) c="0";
            System.err.println("p=" + v);
            System.err.println("c=" + c);
            sum += Integer.parseInt(v) * Integer.parseInt(c);
            System.err.println("T" + row + ":" + "p[" + i + "]*" + "c["
                                    + i + "] => " + v + "*" + c + "+="
                                    + (sum));    }}
context.write(new Text("T" + row), new Text(String.valueOf(sum))); }}
```

<reduce程式碼>

```
public static class HtReduce extends
        TableReducer<Text, Text,
        Text> {
public void reduce(Text key,
        Iterable<Text> values,
        Context context)
        throws IOException,
        InterruptedException {
String sum = "";
for (Text i : values) {
        sum += i.toString();
}
Put put = new
        Put(Bytes.toBytes(key.toStri
        ng()));
put.add(Bytes.toBytes("Turnover"),
        Bytes.toBytes("Sum"), Bytes
            .toBytes(sum));
context.write(new Text(), put);
}}
```

3.3.3. Hadoop 來源與輸出皆為 HBase

< Main 程式碼>

```
public static void main(String args[]) throws
        Exception {
String tablename = "tcrc";
Scan myScan = new Scan();
myScan.addColumn("Detail:Locate".getBytes());
myScan.addColumn("Products:P1".getBytes());
myScan.addColumn("Products:P2".getBytes());
myScan.addColumn("Products:P3".getBytes());
myScan.addColumn("Products:P4".getBytes());
myScan.addColumn("Turnover:P1".getBytes());
myScan.addColumn("Turnover:P2".getBytes());
myScan.addColumn("Turnover:P3".getBytes());
myScan.addColumn("Turnover:P4".getBytes());
Configuration conf = new Configuration();
Job job = new Job(conf, "Calculating ");
job.setJarByClass(tcrc3CalculateMR.class);
job.setMapperClass(HtMap.class);
job.setReducerClass(HtReduce.class);
job.setMapOutputKeyClass(Text.class);
job.setMapOutputValueClass(Text.class);
job.setInputFormatClass(TableInputFormat.class);
job.setOutputFormatClass(TableOutputFormat.class
        );
TableMapReduceUtil.initTableMapperJob(tablena
        me, myScan, HtMap.class,
            Text.class, Text.class, job);
TableMapReduceUtil.initTableReducerJob(tablena
        me, HtReduce.class, job);
System.exit(job.waitForCompletion(true) ? 0 : 1);
}
}
```

```
> scan ‘tcrc’
ROW                    COLUMN+CELL
 T01                   column=Detail:Locate, timestamp=1265184360616, value=01
 T01                   column=Detail:Name, timestamp=1265184360548, value=GunLong
 T01                   column=Products:P1, timestamp=1265184360694, value=20
 T01                   column=Products:P2, timestamp=1265184360758, value=40
 T01                   column=Products:P3, timestamp=1265184360815, value=30
 T01                   column=Products:P4, timestamp=1265184360866, value=50
 T01                   column=Turnover:P1, timestamp=1265187021528, value=1
 T01                   column=Turnover:P2, timestamp=1265187021528, value=1
 T01                   column=Turnover:P3, timestamp=1265187021528, value=1
 T01                   column=Turnover:P4, timestamp=1265187021528, value=1
 T01                   column=Turnover:sum, timestamp=1265190421993, value=140
 T02                   column=Detail:Locate, timestamp=1265184360951, value=02
 T02                   column=Detail:Name, timestamp=1265184360910, value=Esing
 T02                   column=Products:P1, timestamp=1265184361051, value=50
 T02                   column=Turnover:P1, timestamp=1265187021528, value=2
 T02                   column=Turnover:sum, timestamp=1265190421993, value=100
 T03                   column=Detail:Locate, timestamp=1265184361124, value=03
 T03                   column=Detail:Name, timestamp=1265184361098, value=SunDon
 T03                   column=Products:P1, timestamp=1265184361189, value=40
 T03                   column=Products:P2, timestamp=1265184361259, value=30
 T03                   column=Turnover:P1, timestamp=1265187021529, value=3
 T03                   column=Turnover:sum, timestamp=1265190421993, value=120
 T04                   column=Detail:Locate, timestamp=1265184361311, value=04
 T04                   column=Detail:Name, timestamp=1265184361287, value=StarBucks
 T04                   column=Products:P1, timestamp=1265184361343, value=50
 T04                   column=Products:P2, timestamp=1265184361386, value=50
 T04                   column=Products:P3, timestamp=1265184361422, value=20
 T04                   column=Turnover:P1, timestamp=1265187021529, value=2
 T04                   column=Turnover:P2, timestamp=1265187021529, value=1
 T04                   column=Turnover:P3, timestamp=1265187021529, value=1
 T04                   column=Turnover:sum, timestamp=1265190421993, value=170
4 row(s) in 0.0460 seconds
```

3.3.3. 執行結果

	Detail		Products				Turnover				
	Name	Locate	P1	P2	P3	P4	P1	P2	P3	P4	Sum
T01	GunLong	01	20	40	30	50	1	1	1	1	140
T02	ESing	02	50				2				100
T03	SunDon	03	40	30			3	3			210
T04	StarBucks	04	50	50	20		4	4	4		480

3.3.4. 狀況來了

- 管理局想知道餐廳的營運狀況，因此需要產生出最後的報表
  - 資料由小到大排序
  - 過濾掉營業額 < 130 的資料

3.3.4. 回顧 Transactional HBase

- Indexed Table = Secondary Index = Transactional HBase
- 內容與原本table 相似的另一張table，但key 不同，利於排列內容

Primary Table

	name	price	description
1	apple	10	xx
2	orig	5	ooo
3	banana	15	vvvv
4	tomato	8	uu

Indexed Table

	name	price	description
2	orig	5	ooo
4	tomato	8	uu
1	apple	10	xx
3	banana	15	vvvv

3.3.4.回顧： Transactional HBase 環境設定

需在 $HBASE_INSTALL_DIR/conf/hbase-site.xml 檔內增加兩項內容

```
<property>
  <name> hbase.regionserver.class </name>
  <value> org.apache.hadoop.hbase.ipc.IndexedRegionInterface
  </value>
</property>
<property>
  <name> hbase.regionserver.impl </name>
  <value>
org.apache.hadoop.hbase.regionserver.tableindexed.IndexedRegionServer
  </value>
</property>
```

3.3.4.1 建立Indexed Table

```
public class tcrc4SortTurnover {
public void addIndexToTurnover(String OriTable, String IndexID,
        String OriColumn) throws IOException {
HBaseConfiguration conf = new HBaseConfiguration();
conf.addResource(new Path("/opt/hbase/conf/hbase-site.xml"));
IndexedTableAdmin admin = new IndexedTableAdmin(conf);
admin.addIndex(Bytes.toBytes(OriTable), new IndexSpecification(IndexID,
            Bytes.toBytes(OriColumn)));
}
public static void main(String[] args) throws IOException {
tcrc4SortTurnover tt = new tcrc4SortTurnover();
tt.addIndexToTurnover("tcrc", "Sum", "Turnover:Sum");
tt.readSortedValGreater("130");
}}
```

3.3.4.1 Indexed Table 輸出結果

```
> scan 'tcrc-Sum'
ROW                  COLUMN+CELL
 100T02              column=Turnover:Sum, timestamp=1265190782127, value=100
 100T02              column=__INDEX__:ROW, timestamp=1265190782127, value=T02
 120T03              column=Turnover:Sum, timestamp=1265190782128, value=120
 120T03              column=__INDEX__:ROW, timestamp=1265190782128, value=T03
 140T01              column=Turnover:Sum, timestamp=1265190782126, value=140
 140T01              column=__INDEX__:ROW, timestamp=1265190782126, value=T01
 170T04              column=Turnover:Sum, timestamp=1265190782129, value=170
 170T04              column=__INDEX__:ROW, timestamp=1265190782129, value=T04
4 row(s) in 0.0140 seconds
```

3.3.4.2 產生排序且篩選過的資料

```
public void readSortedValGreater(String filter_val)
        throws IOException {
HBaseConfiguration conf = new
        HBaseConfiguration();
conf.addResource(new
        Path("/opt/hbase/conf/hbase-site.xml"));
// the id of the index to use
String tablename = "tcrc";
String indexId = "Sum";
byte[] column_1 = Bytes.toBytes("Turnover:Sum");
byte[] column_2 = Bytes.toBytes("Detail:Name");
byte[] indexStartRow =
        HConstants.EMPTY_START_ROW;
byte[] indexStopRow = null;
byte[][] indexColumns = null;
SingleColumnValueFilter indexFilter = new
        SingleColumnValueFilter(Bytes
            .toBytes("Turnover"),
        Bytes.toBytes("Sum"),
        CompareFilter.CompareOp.GREATER_OR
        _EQUAL, Bytes.toBytes(filter_val));
```

```
byte[][] baseColumns = new byte[][] { column_1,
        column_2 };
IndexedTable table = new IndexedTable(conf,
        Bytes.toBytes(tablename));
ResultScanner scanner =
        table.getIndexedScanner(indexId,
        indexStartRow,
            indexStopRow, indexColumns, indexFilter,
        baseColumns);
for (Result rowResult : scanner) {
        String sum =
        Bytes.toString(rowResult.getValue(column_1)
        );
        String name =
        Bytes.toString(rowResult.getValue(column_2)
        );
        System.out.println(name + " 's turnover is " +
        sum + " $.");
}
table.close();
}
```

3.3.4.2 列出最後結果

- 營業額大於130元者

GunLong 's turnover is 140 $.
StarBucks 's turnover is 170 $.

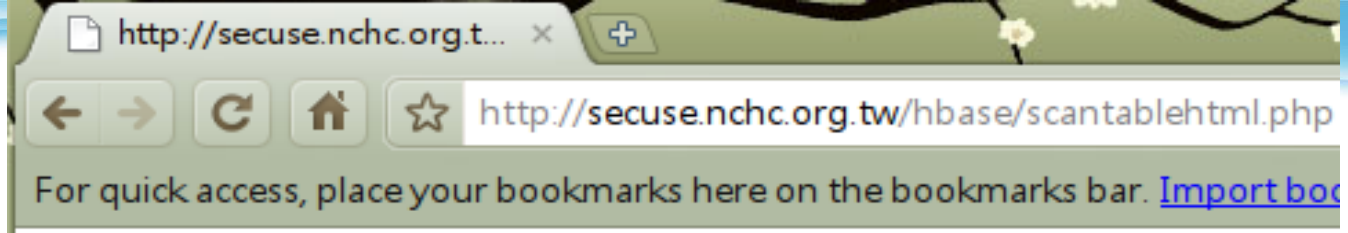
3.3.5. 狀況來了

- 高層嫌報表輸出
  - 只能用cmd
  - 無法直接看
  - 介面....

3.3.5.回顧：還記得 Thrift ？

你可以用任何 Thrift 有支援的語言來直接存取、操作 HBase

- 由 Facebook 所開發
- 提供跨語言做資料交換的平台
- 支援的程式語言
  - PHP
  - Perl
  - C++
  - Python
  - …..



row	Fam:Col	value
T01	Detail:Locate	01
T01	Detail:Name	GunLong
T01	Products:P1	20
T01	Products:P2	40
T01	Products:P3	30
T01	Products:P4	50
T01	Turnover:P1	1
T01	Turnover:P2	1
T01	Turnover:P3	1
T01	Turnover:Sum	90
T02	Detail:Locate	02
T02	Detail:Name	Esing
T02	Products:P1	50
T02	Turnover:P1	2
T02	Turnover:Sum	100

http://localhost/hbase/scantablehtml.php

Conclusions

- HBase 適用於巨量資料的儲存與鬆散框架應用
- 是Hadoop 的開放原始碼子項目
- 叢集模式需Zookeeper 介入
- 提供 shell 的交互操作介面
- 擁有豐富的Java API 讓你能直接寫code存取
- 透過Thrift，你可以用你熟悉的程式語言對HBase 作操控